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ABSTRACT

This reference guide is designed to organize and suggest acceptable practices and procedures for dealing with safety in the area of science instruction. It is intended for use as a reference for teachers, administrators and other school staff for planning science activities and to assist in making safety decisions in a situational context. This guide deals specifically with issues pertinent to the teaching of physics and physical sciences. (Author/RE)

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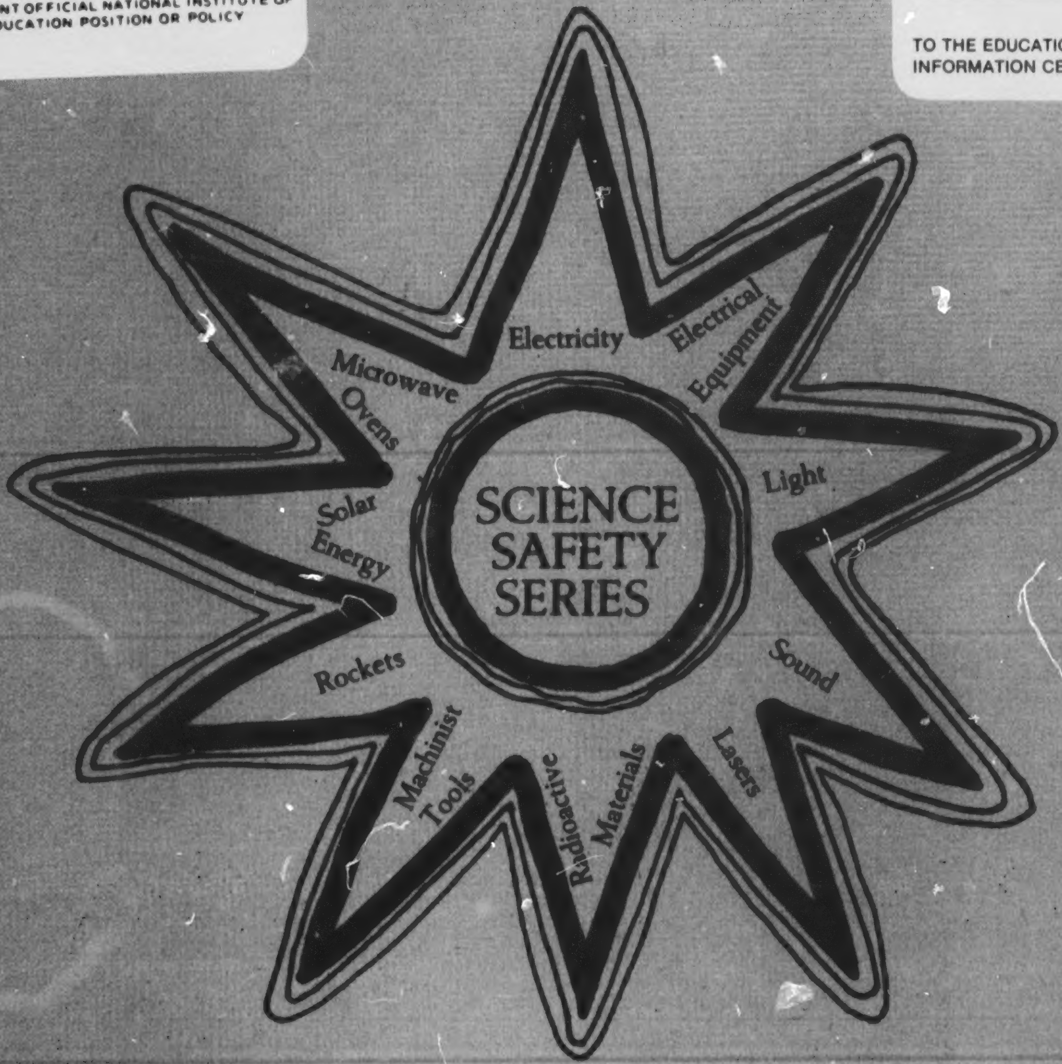
SCIENCE SAFETY SERIES
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Electrical Equipment
Light
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Lasers
Radioactive Materials
Machinist Tools
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Solar Energy
Microwave Ovens

REFERENCE GUIDE
FOR
PHYSICS AND PHYSICAL SCIENCE

Division of Instruction
Oakland Schools
2100 Pontiac Lake Road
Pontiac, Michigan 48054

SE 028 547

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OAKLAND COUNTY
SCIENCE SAFETY SERIES
REFERENCE GUIDE
FOR
PHYSICS AND PHYSICAL SCIENCE

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Oakland County Science Committee
Safety Subcommittee

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The Oakland County Science Safety Series Reference Guides were written during the summer of 1976 and substantially revised during the summer of 1977.

Oakland Schools wishes to express its appreciation to Larry Sabbath, Oak Park School District, for his excellent work on this revision.

Earlier versions were authored by: Larry Sabbath, Oak Park School District, and John Schmitthausler, Lamphere Public Schools.

Oakland Schools also wishes to express its appreciation to:

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Roger Johnson	Waterford School District
Tom Krupka	Farmington Public School District
Betty Pogue Crowder	Rochester Community Schools
Ed Repucci	Walled Lake Consolidated School District
Larry Sabbath	Oak Park School District
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PREFACE

Teachers of science are in a unique position to assist students in understanding and appreciating the importance of safety education. Properly conducted classroom activities, experiments and demonstrations, teachers can show their students how to anticipate and cope with the problems of safety in science. Good instruction can establish a school environment in which safety awareness and practice grows and becomes an integral part of the lives of our students.

With this in mind, the Oakland County Science Safety Series Reference Guides have been developed for the Biological, Chemical, Physical and Elementary areas of science. The Science Safety Series can provide teachers and administrators with specific information in answering questions on safety practices, problems and responsibilities that are most likely to occur in the areas of science instruction, and they also provide assistance in developing a safe laboratory environment that does not, at the same time, unduly restrict scientific inquiry, activity and attitude.

This "Reference Guide" is designed to organize and suggest acceptable practices and procedures for dealing with safety in the area of science instruction. It is intended as a reference for teachers, administrators and other school staff both in planning for science activities and making "on the spot" safety decisions.

It should be emphasized that this guide is only a starting point for good practices. In no way does it intend to establish universal laws, regulations or rules. The contents presented have no legal implications, and should not be read as legal requirements. It is strongly recommended that the reader determine the legal liability of the teacher and/or administrator, as well as, pertinent local, state and federal laws and regulations. Further information on teacher liability can be found in Appendix A.

The working conditions of teachers are protected by the Michigan Occupational Safety and Health regulations (MIOSHA, Act 154 of 1974). Although MIOSHA regulations do not apply specifically to students, they do affect student laboratory safety conditions in an indirect manner. Further information on MIOSHA regulations can be found in Appendix B.

In addition, some school districts have operational statements concerning safety, and it is important that the administrator-teacher be aware of such policies and operating procedures as they relate to science.

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I. RESPONSIBILITY FOR SAFETY

I. RESPONSIBILITIES FOR SAFETY

Introduction

A district-wide science safety program must start at the highest level of administration and continue down through every level of the school community.

The members of the professional staff of the district must recognize and accept their moral and legal safety responsibilities and insist upon safe procedures in all science teaching areas.

Modern science instruction requires the active participation by the students. This raises safety questions not common to the more conventional course of study. Laboratory situations involving student participation are found at all grade levels.

One of the objectives of teaching science is to prepare students to function in a technological society. In such a society, a great many biological, chemical, and physical hazards exist. Therefore, it is natural that any instructional program will expose students to some potential dangers. It is the responsibility of the school to recognize these dangers, bring them to the attention of the students, and still allow the students to experience and discover the wonders of science.

Everyone involved in the administration, or teaching of a science program, should be aware of the federal, state, county, and local laws that apply to science teaching situations. (See Appendix D for listing of Federal and State laws).

Safety involves positive goals. The development and operation of a working safety program requires the active participation of all members of the educational community.

A. ADMINISTRATION

In order to achieve district or school safety goals the administration should:

1. Actively support and display a good attitude toward school safety. Interest must be vocal, visible, and continuous.
2. Establish a written district-wide safety policy and program.
3. Stress and enforce the district-wide safety policy. Hold in-service education sessions with the teachers of science concerning the district-wide safety policy and program. This should include first aid, fire prevention, general student protection (including personal protective equipment), and new safety procedures and considerations. This may mean the appointment of a safety committee and/or safety officers.
4. Be aware of rules governing teacher liability for classroom accidents, and include this topic in in-service and orientation sessions.
5. Assist and encourage the teacher to correct and avoid situations that could result in liability to the teacher and the school.
6. Provide for proper safety equipment in all science laboratories as directed by MIOSHA regulations.
7. Delegate responsibilities to the staff and ultimately to the students. Hold staff accountable for safety practices in their respective areas.
8. Analyze accident records in order to determine the most frequent causes of accidents and the more severe types of accidents. Take corrective measures to change accident-causing conditions.
9. Make safety literature, posters and safety promotional material available to all persons associated with the safety program.
10. Set up a program for the safety orientation for new personnel.
11. Instruct the maintenance department in the proper handling and disposal of science materials.
12. Overcrowding of classes should not be allowed in science laboratories. Consideration of whether overcrowding exists should take into account the physical size of a room, the arrangement of the furniture and the facilities in the room, the kind of activities that are being carried out in the room, and the number of students in the class.
13. Designate a safety officer for the science department.

B. TEACHERS

The real key to safety in the science class is the teacher. The teacher is responsible for being the leader in demonstrating and correlating safe practices in the science areas. The teacher should:

1. Be aware of the district-wide safety policy. Become familiar with implications of MIOSHA regulations as they apply to teaching duties.
2. Adhere to the district-wide safety policy as it applies to the teacher and the students under his supervision.
3. Enforce district-wide safety procedures. This can be carried out by requesting a student practicing an unsafe act or creating an unsafe condition to promptly correct the hazard. Failure to comply could result in suspension or cancellation of lab privileges. Report MIOSHA violations to the proper administrator.
4. Understand the teacher's relationship to the system-wide safety committee or safety supervisor.
5. Maintain safe working conditions, promote safe working methods, enforce the use of personal protective equipment and regulations, and establish the proper attitude toward safety in the classroom. The teacher should have the authority to close down a laboratory for the day, if he feels the environment is hazardous to the students' well-being.
6. Know their spheres of responsibility and authority in the area of safety. Be aware of the teacher's total responsibility in terms of operations, machines, personnel, maintenance, repairs, working conditions, and accident reporting.
7. Notify the administration of a[illegible] potential hazards. Do not allow students to work under unsafe conditions.
8. Determine the qualifications for student assistants. Supervise student assistants.
9. Be aware of the safety considerations for each laboratory activity and instruct the students in this area prior to the start of each exercise.
10. Do not allow the students to experiment on their own without proper supervision.
11. Make safety suggestions to administrative safety supervisor.
12. Review all laboratory manuals to determine the type and extent of hazards introduced by the various experiments and procedures. Analyze all laboratory experiences for possible safety hazards prior to introducing the material to the students.
13. Read and post safety literature, posters and safety promotional material.
14. Assist new teachers in learning and using the school safety code.

15. Know the location of and be able to properly use all science safety devices.

16. Do not work alone in a science laboratory and do not allow students to work alone.

17. Pretest all devices and/or equipment brought into class by a student prior to allowing students to use such devices.

18. Consult people with special knowledge or experience if unsure about using a new technique, chemical, or equipment.

C. STUDENTS

Accidents can be prevented only by each individual working in the laboratory in a safe manner. The students should:

1. Follow the general safety policies of the school district.
2. Maintain safe working conditions as they apply to the individual and the group. Use personal protective equipment and follow personal protective regulations.
3. Be aware of the safety considerations for each laboratory activity prior to the start of each exercise. Follow the safety instructions while performing the laboratory exercise.
4. Survey the student work areas in order to anticipate potential hazards and then take preventive measures and/or report such hazards.
5. Make safety suggestions to the teacher or safety supervisor.
6. Read, learn and follow the safety materials that are posted in the science room.
7. Do not work alone in a science laboratory, or experiment on your own without proper supervision, nor use unfamiliar equipment.
8. Report all injuries to the teacher immediately regardless of how minor.
9. Learn to use science equipment correctly and safely. Work in such a manner that other students are not placed in a potentially dangerous situation.
10. Completely clean up all work areas at the completion of an exercise or laboratory period.

D. MAINTENANCE

The maintenance department of a district or school also has a role in the safety program. The maintenance department should:

1. Be aware of the district-wide safety policy.
2. Establish the maintenance of science areas as a high-priority item. Some responsible person should periodically inspect the science teaching areas for such maintenance items as gas leaks, storage problems, electrical outlets, safety signs, and any other potential hazards.
3. Learn the proper handling and disposal of science materials.
4. Keep all science areas equipped with the necessary science safety materials.
5. Be certain that the science equipment is secure during non-class hours after school, and at night. This is especially important if the school building is used after the end of the normal school day.

II. ELECTRICITY

REFERENCE PAGE FOR ELECTRICITY

Current over 10 milliamps may produce a shock, current over 100 milliamps may be fatal. For a complete discussion of the problem of electric shocks see Statement of Hazard, page 8 .

Room construction is a factor in the safe use of electrical equipment. For information on flooring materials, see Precautionary Measures Do's #2, page 10.

Laboratory circuits should have built in resistance limits. See Precautionary Measures, Do's #4, page 10 .

Students should be taught to handle electric plugs properly. For information on inserting and removing plugs see Precautionary Measures, Do's #5, 6, 9, 10, page 10 .

The electrical master control panel should be readily accessible and clearly labeled. For a complete statement on this topic see Precautionary Measures, Do's #7, 8, page 10 .

All electrical boxes in a room should be completely covered by proper plates. See Precautionary Measures, Do's #12, page 10 .

Do not use any electricity if the equipment or circuit is wet. For a full statement see Precautionary Measures, Don'ts #2, page 10 .

Students should not be allowed to experiment with electricity without close teacher supervision. For statements on this topic see Precautionary Measures, Do's #14, Don'ts #'s 5, 6, page 10 .

Electricity cannot be used in certain areas of a room. For limitations see Precautionary Measures, Don'ts #'s 7, 8, page 10 .

What to do in the case of electrical shock, see Instructions in Case of Electrical Shock, page 11 .

II. ELECTRICITY

Introduction

The use of electrical equipment in science laboratories is universal. Because the possibility of electrical shock exists even with certain low voltages, it is important that basic precautions be taken by persons working with or around electrical circuits. This section concentrates on student constructed electrical circuits, or equipment. The next section deals with the pieces of equipment themselves.

A. DEGREE OF HAZARDS

Prior to using electrical energy consult this section of the Guide. Electrocution can be caused by any voltages since it is the amount of current which flows through the body that determines the effect on the body, and not the amount of the voltage. Any electrical device used on normal wiring can, under certain conditions, transmit a fatal shock. Although it takes a voltage to make the current flow, the amount of shock current will vary depending upon the circumstances at time of contact.

While any amount of current over 10 milliamps (0.01 amp) is capable of producing painful to severe shock, currents between 100 and 200 ma (0.1 to 0.2 amps), while producing severe burns and unconsciousness, do not usually cause death of the victim if given immediate attention. Currents above 200 milliamps (0.2 amp) are absolutely fatal. Individuals have been electrocuted by appliances using ordinary house currents of 110 volts and by electrical apparatus using as little as 42 volts direct current. Voltage, resistance, nature and area of contact, time and path through the human body, are all important factors to be considered when determining electric shock possibilities.

*The voltage at any one place is usually fixed, such as 110 volts or 220 volts, etc. Then the amperage that passes through the body, as a person makes contact with the electrically charged item, is basically determined by the resistance of the human body, as seen in the basic equation:

$$\text{AMPERAGE IN THE BODY} = \frac{\text{VOLTAGE}}{\text{RESISTANCE OF BODY}}$$

Since the voltage is usually fixed, then the amperage becomes greater and greater as the resistance of the human body becomes less and less.

The resistance of the human body to electricity is relatively small, except for the skin. Under certain conditions even the resistance of the skin becomes quite low so that the body is a good path for the electricity and allows sufficient amperage to pass through the body to cause severe shock. One such condition would be to have wet skin (skin resistance may vary from 500,000 ohms for dry skin to only 1,000 ohms of wet skin). Even moisture such as perspiration is a sufficient wetting agent. The moisture helps make a better electrical contact with the item being handled and thereby makes the total resistance low and the amperage through the body high. Another condition that tends to make the resistance of the body low is to have a large area of contact, such as the entire hand, in touch with the object instead of a small area, such as one finger. If a person with dry hands touches a 110-volt line he will receive a very noticeable shock, but normally there will not be sufficient amperage through the body to cause concern. However, if a person's hands are wet and he is standing on a wet surface, thereby making an excellent path for the electricity to the ground, the touching of a 110-volt line could be very dangerous because of the high amperage allowed through the body.

Thus, to avoid trouble with respect to 110-volt lines or other high voltages, the two basic things to be done are:

a. do not allow the body to become the path for the electricity.

b. make conditions such that even though the body does become the path for the electricity, by accident, the amperage will not be dangerously high.

In laboratory work where a 6-volt or 12-volt battery is used, again there is very little danger except for the short circuit condition caused by placing a wire or conductor from one terminal to the other. The wire or conductor may become very hot and there may be flashes and sparks that momentarily scare the student.

The only other likely problem with such batteries would be where they are used in conjunction with something such as a coil where the voltage is increased to proportions where it can give a noticeable shock, but not a particularly dangerous one.

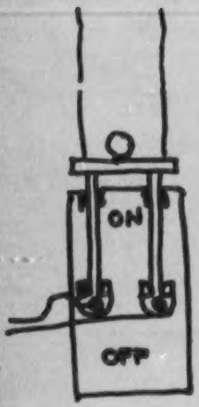
A large part of basic direct current electricity can be taught with the cells and batteries mentioned above and, therefore, can be taught with little or no danger. In storing dry cells, it is good practice to store them with terminals up and free of wire so as to preclude a short circuited cell. It is also good practice to remove flashlight batteries from any electrical device that is not used regularly because many times flashlight batteries leak and severe corrosion takes place. Although "leakproof" batteries should be used, it is still advisable to remove them from unused devices.

As soon as a student plugs into the normal power line of approximately 110 volts, however, the danger potential becomes considerably greater and care should be exercised. A 110 VOLT LINE CAN BE DANGEROUS WHEN IMPROPERLY HANDLED!

*From: Safety In The Science Laboratory. State Department of Education. Tallahassee, Florida. Bulletin 74, 1968.

B. PRECAUTIONARY MEASURES

Do's



1. Handle all electrical circuits with dry hands.
2. Only use electrical equipment while standing on non-metallic floors, rubber mats, or approved carpeting.
3. Be certain that the apparatus is disconnected from the power source and allowed to properly cool prior to touching inside parts.
4. Electric current used in laboratories should be sent through a positive limiting load resistance in order that no more than the desired amount of current will flow under any circumstances.
5. In inserting an electric plug pupils should be instructed to hold the plug so that any flashbacks due to a short circuit will not burn the palm of the hand.
6. In removing an electric plug from its socket, the pupils should be instructed to pull the plug, not the cord.
7. Switches, fuses, circuit breakers and other control devices should be identified that their open and closed positions are quickly recognized, and the circuits that they control should be easily determined.
8. There should be one master switch that is readily available in the room in order to cut off all electricity to all stations.
9. In wiring an electric circuit, the making of the "live" connection should be the last act in assembling and the first act in dismantling the system.
10. Students should avoid bringing both hands into contact with "live" sections of a circuit.
11. Periodic checks should be made for static accumulation in high voltage.
12. Exposed live electrical switches on the front panels of laboratory and preparation room switchboards should be shielded by a wire cover or other protective device whenever pupils have access to such panels.
13. Connections should not be made to light sockets for the purpose of operating electrical appliances, light extensions, or portable equipment.
14. The teacher should check the student-constructed circuit prior to allowing the flow of electricity to begin.

Don'ts

1. Use electrical equipment while in contact with other grounded items or surfaces.
2. Continue to use an electrical apparatus after liquid has been spilled on it. Turn it off immediately and allow it to dry thoroughly inside and out prior to using it again.
3. Change connections while power is on.
4. Touch any part of the circuit while the power is on.
5. Students should not be allowed to "experiment" with electrical circuits and voltages. High voltages and makeshift assemblies team up to cause trouble.
6. Allow students to: construct circuits and/or make connections without teacher supervision, use improper size extention cords, by-pass fuses, use exposed connections, high voltage sources in low voltage situations, etc.
7. Use switches or equipment that spark near volatile substances.
8. Use a unit that is a heating device near flammable liquids, vapors, or open containers of flammable liquids.

C. INSTRUCTIONS IN CASE OF ELECTRICAL SHOCK

1. Call a physician at once.
2. Shut off the current or cautiously remove contact from the victim, using an insulator. Use heavy rubber or asbestos gloves or a hand inside a glass beaker to push the victim or current source aside - a dry stick or dry towel will not suffice.
3. Start artificial respiration immediately.
4. Do not regard early rigidity or stiffening as a sign for ceasing artificial respiration. Efforts for revival should be continued for at least four hours, or until a physician certifies death, even though there is no sign of regaining consciousness.
5. Keep the victim warm, using blankets, hot water bottles against the body.

See also: Appendix I: Safety Talk: "Electric Shock".

References

Laboratory Safety. Department of Environmental Health and Safety. University of Michigan Health Service, Ann Arbor.

Vol. 1, No. 4	Rules of Electrical Safety
Vol. 1, No. 8	Electric Shock from "Discharged" Capacitors Safe Disposal of Mercury Batteries
Vol. 6, No. 9	More on Power Disconnects Bleeding High-Voltage Power Supplies
Vol. 8, No. 12	The Ever Growing Use and Hazards of Electricity
Vol. 10, No. 2	Ground Fault Circuit Interrupters

Modern Chemical Technology, Guidebook. Revised Edition 1972, American Chemical Society, Washington, D.C.

III. ELECTRICAL EQUIPMENT

REFERENCE PAGE FOR ELECTRICAL EQUIPMENT

Electrical equipment will not operate safely if forced beyond its intended limits, when in need of repair, or in a dangerous environment. For further statements on these topics see: Degree of Hazard, page 13 ; Precautionary Measures, Do's #9, 10 page 14 ; Don'ts #'s 3, 4, 10, 11, 12, 16 page 15 .

All electrical equipment should be inspected prior to its use. See Precautionary Measures, Do's #1, 3, 13 page 13 ; Don'ts #2, 13, 14 page 15 .

All electrical equipment should have a 3-pronged plug. See Precautionary Measures, Do's #2, 4 page 13 ; Don'ts #8, 9, 10, 11, 12 page 15 .

The use of an extension cord may create a safety hazard. See Precautionary Measures, Do's #8, 9, 10 page 14; Don'ts #1, 5, 6 page 15.

Electrical equipment should be left intact, with all covers in place, switches working, proper labels for controls, etc. Students should not be allowed to alter the equipment. See Precautionary Measures, Do's #3, 4, 6 page 13 ; Don'ts #13, 14, 16 page 15 .

The National Electrical Code governs the construction of the room where electrical equipment is being used. See Room Regulations, page 16 for a further statement and information on fire extinguishers, Appendix E.

III. ELECTRICAL EQUIPMENT

Introduction

The use of electrical equipment in science laboratories is widespread. It is important that basic precautions be taken by teachers using, or having students use electrical equipment because the possibility of electric shock and fire exists even with low voltages (see Degree of Hazards previous chapter on Electricity).

The fact that experience with the use of electrical power is so common in our society by persons of all ages, should not lull the teacher into a false sense of security and a relaxed attitude toward the student and the equipment. This is especially true if the appliance is easy to operate, or has been used over a long period of time.

Refer to the previous chapter on Electricity prior to allowing students to construct their own electrical circuits.

For a discussion of grounding portable power tools, see Chapter VII Machines and Tools, Portable Power Tool Safety.

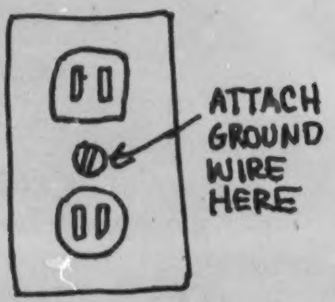
A. DEGREE OF HAZARDS

The hazards connected with the use of electrical equipment are due to the following factors:

1. The continued use of equipment in need of repair.
2. The use of equipment beyond its intended limitations.
3. The lack of understanding on the part of the students as to the potential dangers in the use of a specific piece of equipment by itself, or in connection with other pieces of equipment.
4. Improper or poorly made electrical connections.

B. PRECAUTIONARY MEASURES

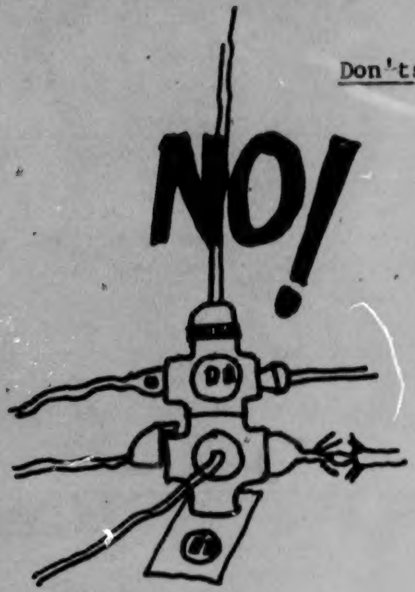
Do's



1. Keep all electrical equipment in top condition - inspect connections, cords and plugs. Damaged cords and plugs should be replaced immediately. Cracked insulation on cords also indicates the need for replacement. Heavy rubber-covered wall plugs will not crack if dropped.
2. Electrical receptacles should be of the grounded type which accept the 3-pronged plug. The ground wire on the plug should be attached to the screw on the face of the plate in order to be functional when attaching a 3-pronged plug to a 2-prong receptacle.
3. Repairing or altering of electrical equipment or wiring should be done by qualified personnel only.
4. Components of electrical equipment should be enclosed to prevent accidental contact with current-conducting

parts, and tampering by students.

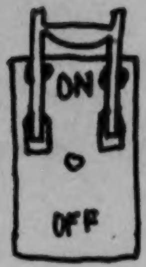
5. Areas with high voltage equipment should be clearly marked and restricted to authorized personnel only.
6. Fusing should be such that overheating or burn-out of equipment or wiring is not possible.
7. Equipment and appliances using 117-120 volts should be equipped with 3-wire grounding cords.
8. All extension cords should be UL approved and properly grounded.
9. Plastic covers of some type are recommended for electrical cords which are used around solvents or oils.
10. If moisture, heat, or chemicals are present, the electrical cord should be the proper type to resist such conditions.
11. All types of induction coils should be clearly marked for the low and high voltage connections in order to avoid the possibility of shocks.
12. All microwave equipment should be measured for possible stray radiation. The testing device should measure at least up to 2450 MH_z. (See Chapter IX Miscellaneous, Microwave Ovens).
13. Power disconnect tags should be used whenever electrical equipment is taken out of service for repair.
14. Periodic checks should be made for static accumulation in high voltage situations.



Don'ts

1. Avoid using household type extension cords in laboratories.
2. Do not attempt to repair or adjust portable electric equipment while it is plugged in.
3. Portable electrical equipment should not be used in the presence of flammable vapors or gases, unless specifically designed for use under hazardous conditions.
4. Do not place or use electrical equipment in unsafe areas; wet surfaces, metallic floors, near flammable volatile materials.
5. Extension cords should not be strung in such a way that they become a tripping hazard.
6. Electrical cords should not be twisted or kinked, and should be protected from sharp objects.
7. Live wires should not be allowed to touch grounded metallic objects.
8. Multiple plugs should not be used in wall outlets.
9. Semi-permanent electrical connections should not be made to wall outlets.
10. Electrical appliances consuming more than 1100 watts should not be connected to wall outlets.
11. Motor-driven apparatus should not be connected to wall outlets unless such apparatus is essentially portable.
12. Under no circumstances should a motor requiring a starting current of more than 1100 watts be connected to a wall outlet.
13. Never substitute a conductor (nail, or penny) for a fuse.
14. Never use an oversized fuse.
15. Do not continue to use any electrical equipment after liquid has been spilled on it. Turn off immediately, disconnect, and allow it to dry thoroughly inside and out prior to using it again.
16. Do not push electrical equipment beyond its limitations; don't overload circuits.

C. ROOM REGULATIONS



Nearly all laboratories contain gas, water and electrical facilities. Master control valves or switches for these should be included in the laboratory. This is especially important for the gas and electricity.

All electrical outlets should carry a grounding connection requiring a 3-pronged plug. All electrical equipment should be wired with a grounding plug. Continuity of grounding connections, including leads to the building ground itself, should be checked periodically by an authorized inspector. The National Electrical Code should be followed in all installations. This includes proper grounding as well as proper equipment for hazardous areas.

The room equipment should include a fire extinguisher of either Class C, or Multi-Purpose Dry Chemical Type.

The floor material should either be wood, or some insulated covering. The students could stand on rubber mats. The development and use of approved carpeting has added an additional margin of safety.

See also: Appendix J: Safety Talk: "Extension Cord Safety".

References

National Electric Code (adopted in total by Michigan, January 1, 1975).
Modern Chemical Technology, Guidebook, Revised Edition, (1972), American Chemical Society, Washington D.C.

IV. LIGHT AND SOUND

REFERENCE PAGE FOR LIGHT AND SOUND

The hazards in light and sound experiments center around the intensity of the energy source, the time of exposure, the physical relationship between the source and the student, and the effect of the energy on the student's senses. For a comment on each of these factors see Degree of Hazard, page 18.

The safe decibel level is about 90. For a discussion of values above 90, see Precautionary Measures - Sound #2, 3, 4 and table under Room Recommendations, pages 18 and 19.

Each student has a different tolerance and adaptability to sound and light energy sources. See Precautionary Measures - Sound #5, page 18, Light #1, page page 20.

Students should not be allowed to use sound and light energy sources without the proper supervision. For guidelines on this topic see Precautionary Measures - Sound #6, page 18, Light #'s 2, 3, 4, 5, 8, page 20.

Ultraviolet (UV) energy sources can be used safely if the danger levels are understood and safety guidelines are followed. See section on Ultraviolet Radiation, pages 20 and 21.

IV. LIGHT AND SOUND

Introduction

Experiments using light and sound energy are found in all physical science and physics courses, at all academic levels. For the most part, the activities do not present any real dangers to the students as long as they use "common sense" and normal levels of precaution. However, there are some dangers when the students go beyond the basic experiments, and the teachers should be aware of these dangers.

The danger in doing experiments with sound and light energy is that the injury to the students can take place without a great deal of pain and, in many cases, without the student even being aware that any injury is taking place.

For a detailed discussion of the use of lasers in the laboratory, refer to the next chapter of this Guide.

A. DEGREE OF HAZARDS

The hazards for the use of sound and light energy center around the following areas:

1. The intensity of the sound and light that is being used.
2. The wave lengths of sound and light energy that are being used.
3. The physical relationship between the student and the energy source.
4. The physiological effect on the student by the energy being used.
5. The length of time that the student is exposed to the sound or light energy.
6. The difference between annoying levels and harmful levels of sound and light.

B. PRECAUTIONARY MEASURES - SOUND

1. Noises which seem to cause the greatest problem seem to be the lower octave bands - especially the 31.5 Hz band.
2. The generally accepted decibel categories are: $60 \rightarrow 80$ = loud; $80 \rightarrow 100$ = very loud; $100 \rightarrow 120$ = deafening. The Permissible Noise Exposure above the 90 decibel level that would apply to laboratory situations are: 105 for 1 hour; 110 for 1/2 hour; 115 for 1/4 hour or less. The noise ceiling is 115 decibels.
3. Hearing loss is less likely to occur when one is exposed to lower frequencies. High intensity sounds in frequencies between $300 \rightarrow 1400$ cps will cause the most hearing loss.
4. Actual physical pain generally starts at 120 decibles.
5. Each student has a different tolerance and adaptability to sound and noise and what may not bother one student may be harmful to another. The teacher should be aware of any hearing or sight problems in the class prior to starting sound and light experiments.
6. The teacher should make the students aware of the dangers of directing sound energy directly into the ear at close range and/or

Rule 2401 Occupational Noise Exposure

(1) Definitions:

As used in this rule:

(a) "Auditory protective equipment" means ear plugs, muffs or other protective devices worn by an exposed person to attenuate airborne noise pressure in the ear canal. [R 325.2404(a)]

(b) "Broad-band noise" means noise generally distributed throughout the sound frequency spectrum. [R 325.2404(b)]

(c) "Continuous noise" means an interrupted noise of more than 60 noises per minute. [R 325.2404(c)]

(d) "dBA" means the airborne sound pressure level measured with the "A" weighting network of a sound level meter. [R 325.2404(d)]

(e) "Decibel" or "dB" means a dimensionless unit expressing the ratio of two sound quantities in logarithmic form, one of which is a reference level of 0.0002 microbar. [R 325.2404(e)]

(f) "Impact noise meter" means an instrument used for the measurement of peak sound pressures of impulse. [R 325.2404(f)]

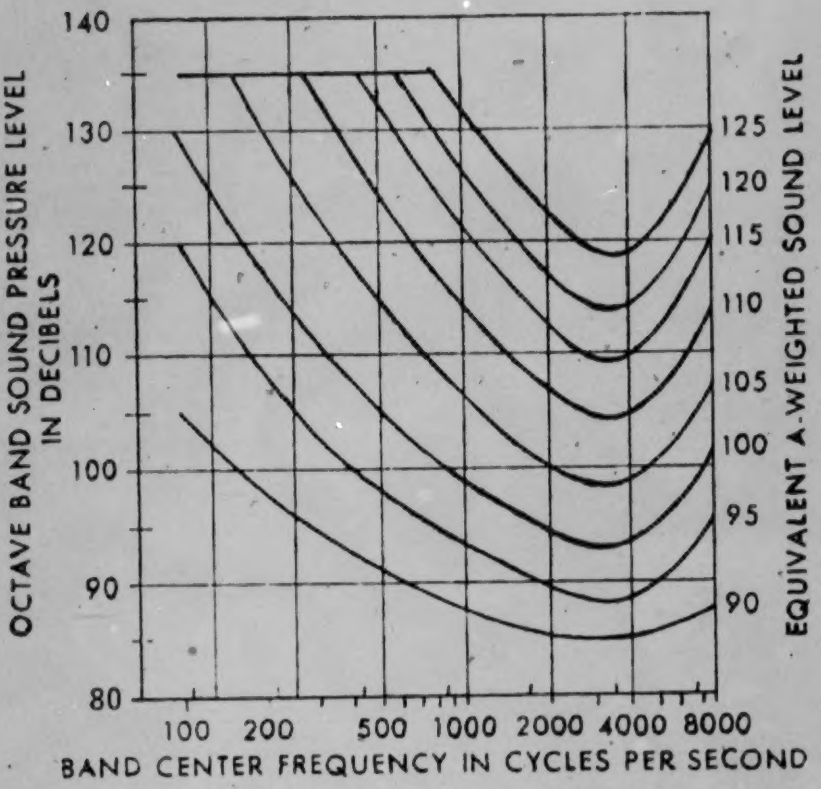
(g) "Impulse noise" means (a single noise or) 60 or less noises per minute. [R 325.2404(g)]

(h) "Noise" means airborne sound in the frequency range from 20 to 20,000 hertz or cycles per second. [R 325.2404(h)]

(i) "Sound level meter" means an instrument, whose characteristics comply with those specified in the American Standards Association, Standard S1.4-1971, used for the measurement of airborne sound pressure level. [R 325.2404(i)]

(2) Protection against the effects of noise exposure shall be provided when the sound levels exceed those shown in paragraph (3)(b), Table G-16 when measured on the A scale of a standard sound level meter at slow response. When noise levels are determined by octave band analysis, the equivalent A-weighted sound level may be determined as follows:

Figure G-9



Equivalent sound level contours. Octave band sound pressure levels may be converted to the equivalent A-weighted sound level by plotting them on this graph and noting the A-weighted sound level corresponding to the point of highest penetration into the sound level contours. This equivalent A-weighted sound level, which may differ from the actual A-weighted sound level of the noise, is used to determine exposure limits from paragraph (3)(b), Table G-16.

[1910.95(a)]

(3)

(a) When employees are subjected to sound exceeding those listed in Table G-16, feasible administrative or engineering controls shall be utilized. If such controls fail to reduce sound levels within the levels of Table G-16, personal protective equipment shall be provided and used to reduce sound levels within the levels of the Table. [1910.95(b)(1)]

(b) Table G-16--Permissible Noise Exposures[1]

Duration per day, hours	Sound level dBA slow response
8	90
6	92
4	95
3	97
2	100
1-1/2	102
1	105
1/2	110
1/4 or less	115

[1] When the daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered, rather than the individual effect of each. If the sum of the following fractions: $C_1/T_1 + C_2/T_2 \ldots C_n/T_n$ exceeds unity, then the mixed exposure should be considered to exceed the limit value. C_n indicates the total time of exposure at a specified noise level, and T_n indicates the total time of exposure permitted at that level.

(c) If a noise level is between two listed maximum permissible noise levels in Table G-16, then Chart A shall be used to determine the permitted daily exposure time. In applying the chart, measured noise levels will be taken to the nearest whole number. [R 325.2421(2)]

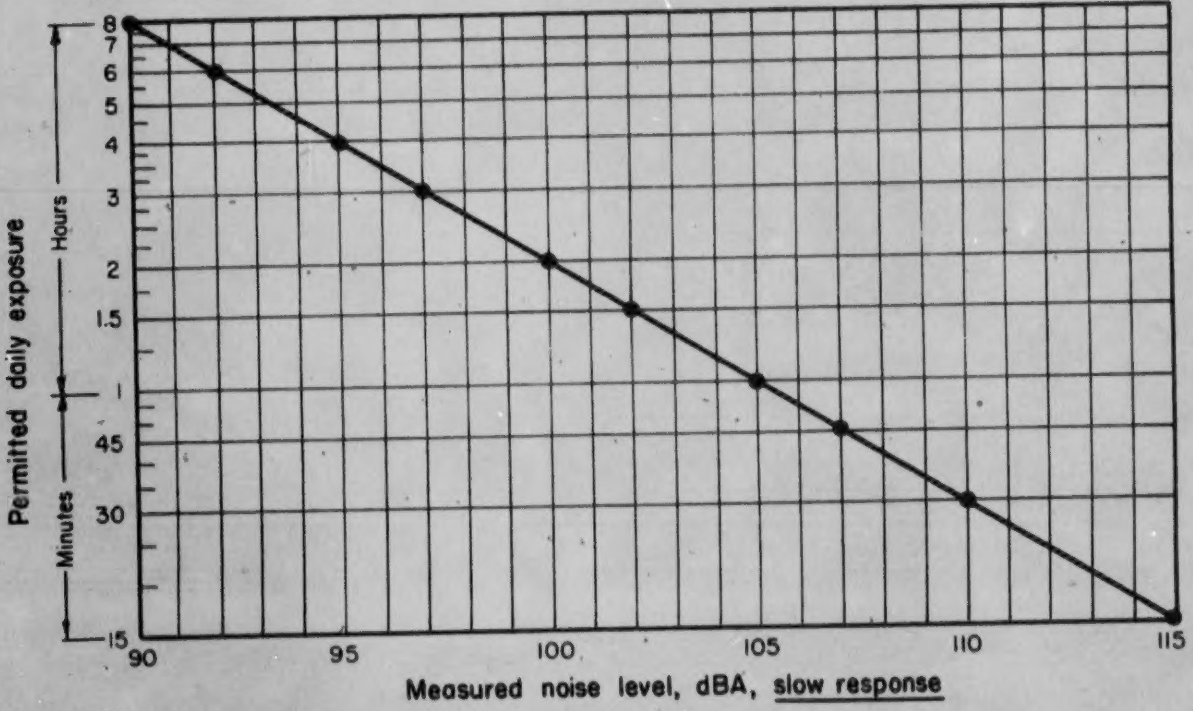


CHART A NOISE EXPOSURE CHART

(d) If the variations in noise levels involve maxima at intervals of 1 second or less, it is to be considered continuous. [1910.95(b)(2)]

(e) In all cases where the sound levels exceed the values shown herein, a continuing, effective hearing conservation program shall be administered. [1910.95(b)(3)]

(f) The following are examples of the use of the formula in accordance with paragraph (b).

$$N = \frac{C_1}{T_1} + \frac{C_2}{T_2} + \frac{C_3}{T_3} + \dots \frac{C_n}{T_n}$$

N = total noise exposure
$C_1, C_2, C_3 \dots$ = actual exposure times in minutes, at different noise levels.
$T_1, T_2, T_3 \dots$ = permitted exposure times in minutes, at different noise levels.

Example #1

5 Hr. = 300 Min. Exposure @ 83 dBA Permissible Time = ∞
2 Hr. = 120 Min. Exposure @ 95 dBA Permissible Time = 4 Hr. = 240 Min.
1 Hr. = 60 Min. Exposure @ 97 dBA Permissible Time = 3 Hr. = 180 Min.

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \frac{C_3}{T_3} = N \qquad \frac{300}{\infty} + \frac{120}{240} + \frac{60}{180} = 0 + .5 + .33 = .83$$

Since N does not exceed 1, the exposure is less than the permissible limit.

Example #2

1 Hr. = 60 Min. Exposure @ 87 dBA Permissible Time = ∞
3 Hr. = 180 Min. Exposure @ 90 dBA Permissible Time = 8 Hr. = 480 Min.
3 Hr. = 180 Min. Exposure @ 95 dBA Permissible Time = 4 Hr. = 240 Min.
1 Hr. = 60 Min. Exposure @ 100 dBA Permissible Time = 2 Hr. = 120 Min.

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \frac{C_3}{T_3} = N \qquad \frac{60}{\infty} + \frac{180}{480} + \frac{180}{240} + \frac{60}{120} = 0 + .38 + .75 + .5 = 1.63$$

Since N is greater than 1, the exposure exceeds the permissible limit.
[R 325.2421(5)]

(4) Impulse Noise

(a) Exposure to impulse or impact noise should not exceed 140 dB peak sound pressure level. [1910.95(b)(3)]

(b) The maximum permissible level for impulse noise shall be 140 dB as measured with a cathode-ray oscilloscope system or with other equipment such as the impact noise meter capable of indicating the maximum instantaneous peak noise level. [R 325.2422] for extended periods of time.

7. The tuning forks that are purchased from the typical science supply catalog are within the safety range. There is little risk in terms of intensity and duration in their normal laboratory use.

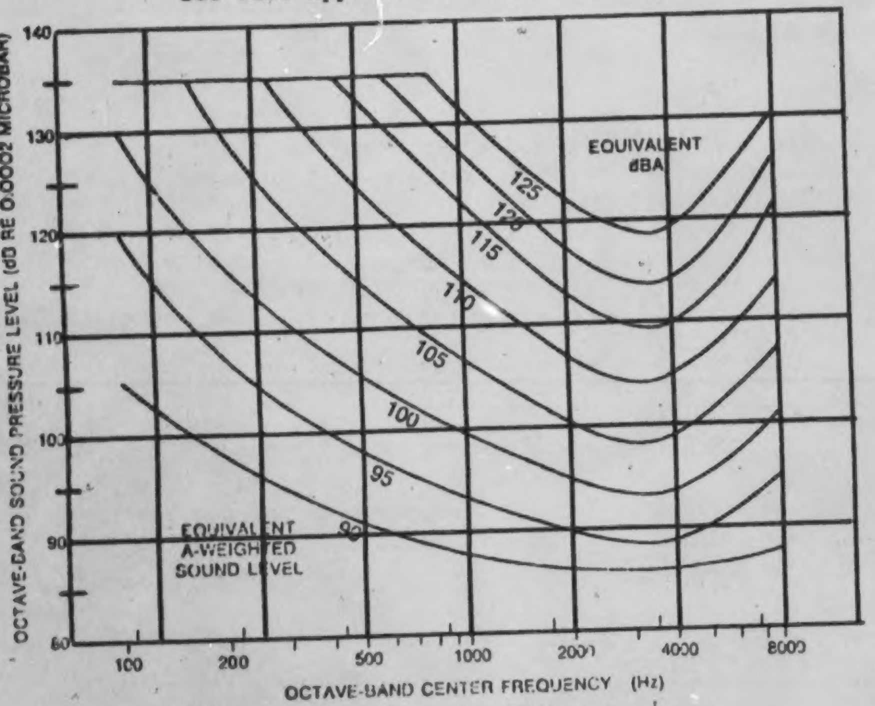
C. HIGH RISK SITUATIONS - SOUND

The high risks encountered in using sound experiments are found in terms of decibel levels, intensity, and duration. The teacher should be aware of the fact that students differ in their tolerance to sound energy.

D. ROOM RECOMMENDATIONS - SOUND

Various methods can be used to reduce intensities and where possible every effort should be put forth to engineer excessive noise out of operations. Where this is not possible, it is necessary for students to use either ear muffs which cover the ear or use "insert-type" plugs. Ear muffs provide greater attenuation of sound.

It should be understood that the sounds from a source of noise radiates to various parts of a room and room characteristics determine the extent to which sound waves are reflected from floors, walls, and ceilings. This, of course, influences the sensations experienced by the listener. See also Appendix K: Safety Talk: "Hearing Safety".



CONTOURS FOR DETERMINING EQUIVALENT A-WEIGHTED SOUND LEVEL

TABLE 1

Permissible Noise Exposures[1]

Duration per day, hours	Sound level dBA slow response
8	90
6	92
4	95
3	97
2	100
1½	102
1	105
½	110
¼ or less	115

[1] When the daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered, rather than the individual effect of each. If the sum of the following fractions: C1/T1 + C2/T2 . . .Cn/Tn exceeds unity, then, the mixed exposure should be considered to exceed the limit value. Cn indicates the total time of exposure at a specified noise level, and Tn indicates the total time of exposure permitted at that level.

From - Laboratory Safety, Vol. V, No. 3.

E. PRECAUTIONARY MEASURES - LIGHT

1. The teacher must remember that each student will have an individual tolerance and adaptability to light energy.
2. The teacher should make the students aware of the dangers of shining high intensity lamps or strobe lights directly into the eye.
3. The teacher should make the students aware of the dangers of shining light directly into the eye for extended periods of time.
4. The teacher should caution the students against the dangers of placing lenses and/or combinations of lenses between their eyes and the source of light.
5. The teacher should be aware of the dangers of using various types of light source (mercury vapor, spectrum tubes, metallic arc lamps, etc.)
6. The teacher should be aware of students wearing contact lenses and how these lenses change the response of the eye to certain types of stimuli. See References in this section for articles on the subject of the danger of wearing contact lenses in science laboratories.
7. Students should not be instructed to look directly into the sun with the naked eye, and especially not through a telescope or the pinhole camera.
8. The Microwave Optic Kits that are found in the typical science supply catalog are within the safety range. The teacher must caution the students against directing the energy toward the body for any length of time. The students should not be allowed to alter the range or construction of the energy source.

F. HIGH RISK SITUATIONS - LIGHT

The high risks encountered in doing light experiments are found in situations where the teacher is not aware of the danger in using metallic arc light sources especially with certain lens combinations. Students should be warned against looking directly into the light source, with or without intervening lenses. The teacher should not allow the students to experiment freely while looking directly into the light source, or by directing light energy on flammable or explosive materials.

G. ULTRAVIOLET RADIATION

1. Introduction

Occassionally physical science courses perform experiments using ultraviolet radiation sources. The primary sources for the energy are germicidal lamps. The radiation generally is between 390 millimicrons and 1800 millimicrons.

2. Statement of Hazards

Unless exposure is severe, injuries, mainly to the eye, caused by exposures are transitory. Symptoms occur several hours after exposure. Exposure should not exceed 0.5 microwatts/cm^2 or 0.0005 watts/ft^2 at the face for a maximum of seven hours or less per day. The shortest UV, below about 3100 Å is most harmful to the eyes.

3. Precautionary Measures for Use of UV Sources

   a. Do not look directly into the UV lamp for an overdose can cause detachment of the retina.
   b. The UV lamp should be properly shielded and should not be allowed to reflect off surrounding surfaces.

   See Chapter IX on Miscellaneous for a discussion of Solar Energy experiments.

   See Appendix L: Threshold Limit Values.

References

1. Laboratory Safety. Department of Environmental Health and Safety. University of Michigan Health Service, Ann Arbor.

Vol. 3, No. 2	Contact Lenses and Laboratories
Vol. 5, No. 9	More on Contact Lenses in Laboratories
Vol. 5, No. 7	Noise
Vol. 7, No. 4	Ultraviolet Radiation
Vol. 7, No. 7	How Much Noise Is Too Much Noise?
Vol. 7, No. 12	Ear Protection

2. Laboratory Safety. Edited by Eric W. Spencer, Safety Officer. Brown University. Providence, Rhode Island. Vol. V, No. 3 Noise Control.

3. Handbook of Laboratory Safety. 2nd Edition. The Chemical Rubber Co. Cleveland, Ohio.

V. USE OF LASERS

REFERENCE PAGE FOR USE OF LASERS

The greatest safety concern in using lasers is possible damage to the eyes. For guidelines on eye safety, see Degree of Hazard, page 23 , and Precautionary Measures #'s 3, 4, 5, 9, 13 and 14 pages 24 and 25.

Lasers can also cause other types of injuries. For a discussion of non-eye injuries, see Degree of Hazard, page 23 , and Precautionary Measures #'s 8, 10, and 15, pages 24 and 25.

The area where the laser is used must be carefully designed and controlled for maximum safety to the teacher and students. For guidelines on room design and organization, see Precautionary Measures #'s 2, 4, 5, 6, 11, 12, and 19 pages 24 and 25.

V. USE OF LASERS

Introduction

Experimentation involving the use of lasers in the laboratory should be conducted in an atmosphere of careful safety precautions. The teacher should be aware of the potential dangers involved in using these instruments and prepare the laboratory exercises accordingly. It is recommended that the teacher be completely familiar with the operation and potential safety hazards involved in the use of these devices before conducting laser experiments.

The American Conference of Governmental Industrial Hygenists has adopted threshold limit values for continuous wave and modulated beam helium/neon lasers.

> The values have been established for 6943Å lasers (Q switched and Non-Q switched laser energy); and continuous wave laser energy in the 4000Å to 7500Å region of the spectra. These threshold limits apply to direct illumination of specular reflected energy at the cornea of the eye.
>
> Also included is the threshold limit value for skin, levels of laser energy in the visible, near infrared, and infrared portions of the spectra.
>
> The threshold limit values should be considered as guides in controlling exposure to laser energy rather than fine lines between safe and dangerous levels.

It is suggested that anyone interested in additional information concerning threshold unit values, contact the Department of Environmental Health and Safety, the University of Michigan Health Service, Ann Arbor.

A. DEGREE OF HAZARDS

The potential hazards of laser beams to eyes is dependent on laser power, beam diameter, distance from the beam, color of the light, angle of the beam, focal length of the eye, and diameter of the eye opening.

It is generally agreed, that the greatest hazard involved in laser operations is eye damage. Exposure of the retina to laser radiation of one millijoule per cm^2 for ½ millisecond (ruby configuration) has caused retinal burns. The poor reflective characteristics of transparent eye tissue and the excellent reflective characteristics of the tissue increase the possibility of retinal damage.

Additional hazards include first and second degree burns (exposure to beams from high-powered solid state or junction lasers), electric shocks and burns caused by input power or capacitor discharge, burns caused by liquid gas coolants, X-rays given off by equipment and fires.

B. PRECAUTIONARY MEASURES FOR USING LASERS

1. All persons in the area where lasers are being used will be informed about the potential eye hazard of accidental exposure to laser beams.

2. A sign on the door should be posted to identify a laser laboratory. The sign will also instruct visitors to knock and wait at the unopened door to obtain permission to enter.

3. Direct viewing of Q switched or pulsed laser beams is prohibited. Visual alignment of these sources will not be attempted while the power supply is energized. Protective goggles will be worn at all times when working with Q switched or pulsed lasers, and with any laser producing radiation outside the visible region of the spectrum.

4. Laser beam reflection from an efficient mirror may be every bit as dangerous as direct exposure to a laser beam. This reflection may be from such innocuous objects as door knobs, polished table tops or walls. All lasers, at any power level, can produce eye damage. To minimize the chance of accidents due to reflections, it is suggested that eye protections be worn when using any laser beam carrying more than 100 mio of potential power in any portion of the spectrum (visible or outside). GLASSES USED MUST BE CERTIFIED AS PROTECTIVE DEVICES FOR USE WITH LASERS.

5. Keep the level of general illumination high in areas where lasers are operated. Darkened rooms cause the pupils of the eyes to dilate, and thus increase the amount of energy that may inadvertently enter the eye.

6. All screens and metal surfaces used during laser demonstrations should be diffuse white matter and fire-resistant. Precautions should be taken to prevent any type of specular reflection during a demonstration.

7. Keep laboratory personnel a reasonable distance away from all sides of the anticipated path of the laser beam.

8. Design the laser setups to avoid accidental pulsing of the laser and to minimize the possibility of electrical shocks from storage capacitors, power supplies and other equipment.

9. Never look directly into the primary beam or at the pump source.

10. The pumping light of a solid state laser must be shielded because of its high intensity output. Sources which emit ultraviolet or infrared radiation must be shielded.

11. Fire and explosions may occur if the beam is misdirected and strikes a flammable or explosive object. The area of use should be checked for potential hazards.

12. Personnel should ensure that they are between the laser and an exit from the laboratory.

13. Never aim a laser with the eye. Looking along the axis of the laser beam increases the hazard from reflections.

14. Be especially cautious around lasers that operate in the infrared. These beams are invisible to the human eye. They can consequently cause many small lesions in the eye without the victim's being aware that damage has occurred until the loss of sight becomes noticeable.

15. DO NOT let the laser beam strike exposed skin surfaces.

16. Add a cover or cap to block the laser beam when it is not in use during an experiment. The beam should be allowed to radiate only when measurements or observations are being taken.

17. Prepare and test demonstrations without others present.

18. The laser should be equipped with a key switch in the primary circuit.

19. DO NOT leave an operable or unattended laser in the demonstration area.

C. SAFETY CONSIDERATIONS

Anyone who is working in laser test procedures and anyone who may be frequently exposed to laser discharges should have thorough general ophthalmological examinations at regular intervals. These examinations should include fundiscopic studies and mapping of visual fields. See also: Appendix L: Threshold Limit Values.

References

1. Laboratory Safety. Department of Environmental Health and Safety. University of Michigan Health Service. University of Michigan. Ann Arbor, Michigan
    - Vol. 1, No. 2 Lasers - Safety Considerations
    - Vol. 4, No. 4 Laser Hazards - Eyes
    - Vol. 4, No. 9 Ocular Hazards of Lasers
    - Vol. 5, No. 1 Safety Factors in Laser Operations
    - Vol. 9, No. 2 Eye Examinations for Laser Operations

2. Safety in the Science Laboratory for Science Teachers. Safety Education and Training Bureau of Safety and Regulation. Michigan Department of Labor, 300 East Michigan Avenue, Lansing, MI 48913.

3. Office of Information, Bureau of Radiological Health. Food and Drug Administration, 5600 Fishers Lane, Rockville, MD 20852, Bulletin #RH-50.

4. "Safety Rules for a Laser Laboratory", Safety Education and Training Division. Bureau of Safety and Regulation. Michigan Department of Labor. Lansing, MI (1975)

5. Handbook of Laboratory Safety, Second Edition. The Chemical Rubber Company, Cleveland, Ohio.

VI. USE OF RADIOACTIVE MATERIALS

REFERENCE PAGE FOR USE OF RADIOACTIVE MATERIALS

There are three different classes of radiation injuries. For a discussion of these classes and the two types of exposure, see Degree of Hazard, page 28 .

Radioactive sources may be purchased in several different forms. For a discussion of the forms see Purchasing of Radioactive Materials, page 29 .

Radioactive materials must be carefully stored in order to protect teachers and students from radiation injuries. Guidelines for storage are discussed in the section on Storage of Radioactive Materials, page 29 .

Students can use radioactive materials safely if they will take simple precautions. For a list of such precautions see Precautionary Measures #'s 3, 4, 5, 8, 9, 12, 13, and 16, pages 30 and 31.

Good housekeeping techniques are especially important when using radioactive materials. For suggestions see Precautionary Measures #'s 6, 11, and 17, pages 30 and 31.

When performing a radiation experiment the clean-up procedures are as important as any other part of the exercise. For clean-up procedures see Precautionary Measures #'s 10, 14, 15, 18, and 19, pages 30 and 31.

There are specific rules governing the disposal of radioactive wastes. These are discussed in the section entitled Waste Disposal of Radioactive Materials, page 31 .

Ionizing radiation injuries can be produced by UV, X-ray, and other electron beam tubes. For cautions in this area see Precautionary Measures, page 33 .

VI. USE OF RADIOACTIVE MATERIALS

Introduction

A wide variety of experiments involving radiation and radioactive materials are available for physical science courses. All of these investigations are designed to employ the use of low level radiation materials. It is important that reasonable safety precautions for radiation safety be maintained when conducting experiments that involve the use of these materials.

The U.S. Atomic Energy Commission has approved weak radioactive isotopes for classroom use without special license. The approval for the use of these weak radioactive isotopes was given after careful consideration of the hazards high school students could potentially encounter.

The use of most other radioactive material or ionizing radiation equipment must be registered and licensed by the Michigan Department of Public Health in accordance with regulations adopted under the authority of Act #88, P.A. 1943. This includes all sources of ionizing radiation, regardless of level. Anytime high voltages lead to high speed particles being produced, registration may be necessary.

The levels of radioactivity of releasable isotopes must be small enough (low microcuric range) so that no elaborate safety equipment or protective measures are required. However, in the interest of absolute safety and to promote proper student handling techniques of radioactive isotopes, it is suggested that the reader consult the "Regulations Governing the Use of Radioactive Isotopes and Ionizing Radiation" published by the Michigan Department of Public Health and obtain a copy of the Instructional Aid: How to Handle Radioisotopes Safely from NSTA.

A. DEGREE OF HAZARDS

Radiations from radioactive substances present very different hazards because they cannot be detected by the human senses. Radiation can be detected with special instruments which permit us to recognize these hazards and protect ourselves against them.

Radioactive materials emit energy which has the power to damage living tissue. All radiation can do damage to the body if it is received in large enough doses. But, within certain limits, the damage can be repaired by the body so that there is no apparent effect. It is safe to work with radiation if the proper limits of radiation are maintained in the working area.

We must realize that radiation has always been a part of our environment. The main difference between natural radiation and man-made radiation is that the man-made sources can be very, very strong.

Basically, two types of exposure to radiation are possible: the radiation source can be external to the body, or it can be internally deposited, either by ingestion or entry through other openings in the body. An overdose of radiation on the body has several effects.

VI. USE OF RADIOACTIVE MATERIALS

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Basically, two types of exposure to radiation are possible: the radiation source can be external to the body, or it can be internally deposited, either by ingestion or entry through other openings in the body. An overdose of radiation on the body has several effects.

Radiation sickness is produced by a massive overdose of penetrating external radiation. It causes nausea, vomiting, diarrhea, malaise, infection, hemorrhage and, if serious enough, it can cause death.

Radiation injuries occur from overdoses of less penetrating radiation that injures a small part of the body. Examples are burns, loss of hair and skin lesions. It happens most often to the hands because contact is usually made with the hands. Radiation can also cause genetic damage.

Radioactive poisoning occurs when dangerous amounts of certain types of radioactive materials enter the body, causing such diseases as anemia and cancer.

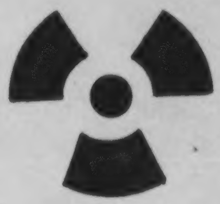
For a complete discussion of radiation hazards see: Modern Chemical Technology Guidebook, Revised Edition (1972), American Chemical Society, Washington D.C.

B. RADIOACTIVE MATERIALS REGISTRATION AND LABELING TECHNIQUES

All radioactive materials that are received should be registered with the state health commissioner by the person effectively in control of such source while it is being stored or used in the State of Michigan. Registration forms are obtainable through the Michigan Department of Health and must be filed within 10 days after receipt of said materials.

Radioactive materials that are received should be clearly labeled with the printed name of the radioactive substance, marked with the radiation caution symbol and labeled with the words "Caution Radioactive Materials."

RADIATION SYMBOL



Information indicating the level of radioactivity for a particular date should also be included on the label.

C. PURCHASING OF RADIOACTIVE MATERIALS

Radioactive sources can be purchased either as sealed sources, or as unsealed sources. The sealed sources consist of the material permanently imbedded within a plastic, metal, or other medium. Such sources are easier to handle and are much safer to use than unsealed sources of the same material.

Another advantage of a sealed source is that the disk is generally labeled with pertinent information such as date of manufacture, identity of the isotope, and its microcurie strength.

Unsealed sources are usually supplied in the form of aqueous solutions, or dry powders. The material may also contain either a "carrier" in order to prevent absorption from solution, or an additive in order to suppress the formation of undesirable chemical forms of the radio element.

D. STORAGE OF RADIOACTIVE MATERIALS

Most radioactive materials, up to and including millicurie quantities, can be stored safely in the original containers. License-free sources are usually supplied in a glass bottle enclosed in a thin metal or cardboard can. This amount of shielding is quite adequate for the quantities involved. Larger quantities of radioactive materials are supplied in glass bottles enclosed in small lead containers. These lead containers provide adequate shielding for millicure quantities of radioactive materials, even those which emit gamma rays. Ordinary building bricks, staggered around the sources in a double row, provide additional shielding of stored samples. This method of shielding is far less expensive than the use of lead bricks, but about five times the thickness is required to provide the same degree of shielding.

Small wooden, plastic, or sheet metal cabinets make excellent storage facilities for small quantities of radioactive materials. Cabinets about the size of an ordinary laboratory drying oven may be easily constructed in the school shop or purchased from commercial sources. A small lock is suggested to forestall the curious eyes of the young or other unauthorized personnel. The materials must be secured against pilfering.

The smaller sealed sources may be kept in plastic boxes such as those obtainable from supply houses and pharmacists. In many cases, especially with alpha and weak beta sources, this thin plastic box will provide sufficient shielding for safe storage.

Of course, all containers, boxes, lead shields, and cabinets should be marked with the proper yellow-and-magenta warning labels approved by the Atomic Energy Commission.

*From: Instructional Aid: How to Handle Radioisotopes Safely. National Science Teachers Association. Washington, D.C.

E. PRECAUTIONARY MEASURES FOR USING RADIOACTIVE SUBSTANCES

1. The three methods of protecting against external radiation are time, distance, and shielding.
2. When dispensing radioisotopes to students, the teacher must know the quantity students may be expected to handle with relative safety.
3. Avoid getting radioactive isotopes and radiant paint materials near the mouth, eyes, or open sores.
4. Use tweezers or gloves when handling radiant paint materials.
5. Avoid inhalation of fumes from reactions involving radioactive materials. Such reactions should be carried out under ventilating hoods.
6. Spread waterproof paper over working area to simplify "clean-up".
7. If a student should bring a radioactive specimen to the laboratory, check its level of activity to be certain that it is not dangerously high. Several of the references listed at the end of this section contain charts of acceptable microcuric ratings.

*8. Eating, drinking, and the use of cosmetics in the laboratory are not permitted.

*9. Pipetting or the performance of any similar operation should not be done by mouth suction. Special suction devices are available for use with pipettes.

*10. Before a worker leaves the laboratories, the hands should be washed first, then checked with a beta-gamma survey meter. Contamination remaining after thorough washing should be reported.

*11. If, in the course of work, personal contamination is suspected, a survey with a suitable instrument should be made immediately. This should be followed by the required cleansing and a further survey. Routine precautionary surveys should be made at intervals.

*12. Rubber gloves must be worn at all times while in the laboratory.

*13. The dosimeter or film badge should be worn, if required.

*14. Active liquid wastes should be poured into the labeled beakers provided. They should NEVER be poured into a standard drain. The student should not discard radioactive materials into a standard drain because:

  a. Records must be kept of disposed materials to assure compliance with the regulations.
  b. A special drain should be set aside for the disposal of radioactive waste. The waste sink selected should have minimal exposed drainpipe to minimize radiation hazards from potential buildup of radioactive material in the pipe. A specific sink should also be used to avoid unnecessary contamination of other sinks and waste lines.

*15. Active solid wastes and contaminated materials should be placed in trash cans labeled "contaminated."

*16. All wounds, spills, and other emergencies should be reported to the instructor immediately.

*17. Good housekeeping is encouraged at all times. Spillage should be prevented, but in the event of such an accident the following procedure should be followed:

  a. The liquid should be blotted up. (Wear rubber gloves.)
  b. All disposable materials contaminated by the spill and the cleaning process should be placed in a "contaminated" can.
  c. The area of the spill and the type of activity (e.g. ^{131}I) should be clearly marked.

*18. In general, active materials and contaminated materials are to be retained within the radioisotope laboratory and at specific points within the laboratory.

*19. Before leaving the laboratory, be sure all written records, if required, have been completed.

*From: Instructional Aid: How to Handle Radioisotopes Safely. National Science Teachers Association. Washington, D.C.

F. WASTE DISPOSAL OF RADIOACTIVE MATERIALS*

The "Rules and Regulations" of the Atomic Energy Commission provide several ways for the disposal of radioactive waste. These are:

  a. by transfer of the waste to an authorized recipient, such as a licensed commercial radioactive waste collection service,
  b. by any method desired by the user not otherwise authorized by the regulations, provided special approval has been granted by the AEC,
  c. by release into sanitary sewerage systems, and
  d. by burial in soil.

The regulations also stipulate that radioactive materials SHALL NOT be disposed of by incineration except as specifically approved by the Commission.

There is one additional method for the disposal of radioactive waste not mentioned in the regulation, namely; radioactive decay. If the radioactive material is stored safely for a period of one half-life, half of the problem of waste disposal disappears, and in another half-life period, half of the remaining problem disappears. Nevertheless, when one considers that only about 0.1 percent of the original radioactivity remains after 10 half-life periods, a substantial reduction of the waste disposal problem has been achieved.

For the average small user of radioisotopes it is suggested that radioactive liquid waste and radioactive solid waste be collected in separate containers. Glass or plastic narrow-mouthed bottles are convenient for the collection of radioactive liquids. A funnel is placed in the neck of the bottle to minimize spillage. Wide-mouth containers, beakers, bottles, or step-on metal cans with plastic bag liners are used for the collection of solid waste. Each container should be labeled for identification. It is advantageous to keep short-lived waste separated from long-lived waste so one can take full advantage of radioactive decay as a means of disposal.

Liquid wastes can be discarded through the sanitary sewerage system. A separate sink should be reserved for this purpose and the type and amount of each isotope must be known so the diluted quantities will not be exceeded. Materials discarded through the sanitary sewerage system must be either soluble or dispersible.

When averaged over a period of a day, the concentration of a specific soluble isotope released to the sewer must not exceed set values. Under no circumstances must the gross quantity of material discharged to the sewer exceed one curie per year. These regulations are sufficiently liberal that the average user of small amounts of radioisotopes should have no difficulty disposing of liquid waste. The disposal of solid waste is a little more troublesome, but good laboratory techniques can minimize this problem. Care should be used not to dilute radioactive waste with nonradioactive waste in order to keep the bulk to a minimum. For example, bulk can be reduced by localizing contamination as by placing contaminated pipettes on small facial tissues, thus keeping the underlying heavy protective paper on the desk top clean.

It is especially helpful to keep short-lived solid waste separated from long-lived solid waste. In practice, it is safe to say that license-free quantities of isotopes will have decayed to an undetectable level in about 10 half-lives.

*From: Instructional Aid: How to Handle Radioisotopes Safely. National Science Teachers Association. Washington, D.C.

G. PRECAUTIONARY MEASURES FOR USING ULTRAVIOLET AND IONIZING RADIATION

Laboratories using equipment that may produce ionizing radiation, such as cathode ray tubes and x-ray machines, should use extreme caution to preclude exposure to individuals. When purchased from commercial suppliers such devices will undoubtedly have warnings and precautions that must be followed. When such devices are put together by students or teachers there may be radiation taking place that has not been considered. When high voltages lead to high speed particles being produced, consideration should be given to possible ionizing radiation and proper checks should be made.

The installation of ultraviolet lamps requires some forethought, and often shielding is necessary to protect personnel. The reflectance factors of surrounding surfaces must also be considered. Exposure to UV radiation should not exceed 0.15 microwatts/cm^2 or 0.0005 watts/ft^2 at the face for seven hours or less per day.

Any laboratory using radioactive equipment or ultraviolet radiation should have on hand and use the following guides and references.

(Also see Chapter IX Miscellaneous: Electron Beam Tubes)

References

1. "Radiation Protection in Educational Institutions," Reports #32, 35. National Council on Radiation Protection and Measurements, P.O. Box 4867, Washington, D.C. 20008

2. "Regulations Governing the Use of Radioactive Isotopes, X-Radiation and all Other Forms of Ionizing Radiation". Michigan Department of Public Health, Lansing, Michigan (Revised July 1965)

3. The National Council on Radiation Protection and Measurement. P.O. Box 4867, Washington, D.C. 20008

4. Safety Education and Training Division. Bureau of Safety and Regulation. Michigan Department of Labor, 300 East Michigan Ave., Lansing, Michigan 48926

5. Instructional Aid: How to Handle Radioisotopes Safely. National Science Teachers Association, Washington, D.C. 1971 (#471-14616)

6. Ionizing Radiation. Rule #2410, Michigan Department of Public Health, Lansing, Michigan, 1975

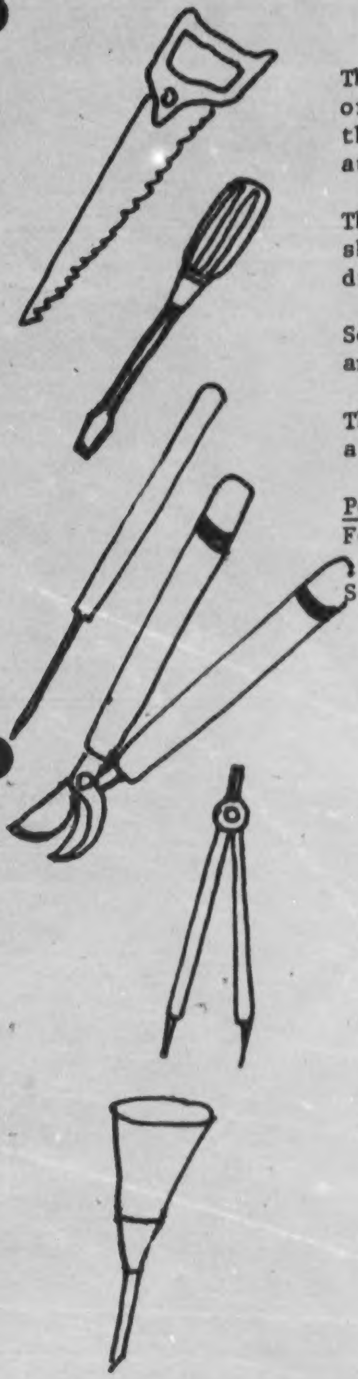
7. "Laboratory Safety", Department of Environmental Health and Safety, University of Michigan Health Service, Ann Arbor, Michigan Vol. 1, No. 12 Ultraviolet Radiation and Eye Injury

8. Modern Chemical Technology, Guidebook, Revised Edition (1972) American Chemical Society, Washington, D.C. (1972)

9. Handbook of Laboratory Safety, 2nd Edition. The Chemical Rubber Co. Cleveland, Ohio

VII. MACHINES AND TOOLS

REFERENCE PAGE FOR MACHINES AND TOOLS



The fact that the device being used is either a simple tool, or commonly used does not mean that the teacher should assume that no safety risk exists. For a discussion of the proper attitude see Introduction, page 35 .

The safety consideration for use of machines and tools should include the clothing worn by the student. For a discussion of this topic, see Degree of Hazard, page 35 .

Some common laboratory machines make use of pumps, compressors, and gauges. For comments on each of these devices see pages 36 and 37.

There are some guidelines for using common hand tools. For a review of safety considerations see pages 38 and 39.

Portable power tools contain their own unique safety problems. For safety guidelines see Precautionary Measures, page 39 .

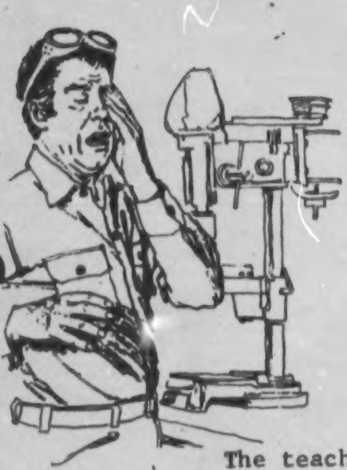
See Appendix N for Safety Talk on "Compressed Air".

VII. MACHINES AND TOOLS

Introduction

Physical science curriculums require the use of many varieties of motors, energy powered devices and energy sources. Many of these objects have use limitations engineered into the device.

The teachers must be certain that they fully understand the limitations and dangers of any object or procedure that is used by or with students. If the teacher does not feel secure in using any powered device or energy source, then the teacher should contact the manufacturer and request specific safety information concerning that piece of equipment. After the information is received it should be either placed with the equipment, or stored in a safety file for future use and reference.

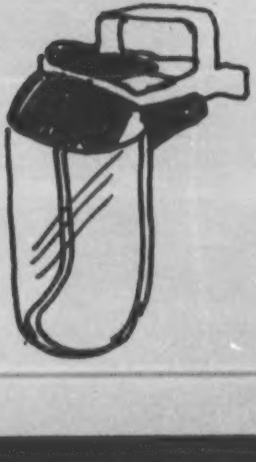


Once the teacher understands the safety aspects of any laboratory tool or procedure, then he must communicate this information to the student prior to the start of the classroom activity. The teacher should not rely on the fact that the authors of laboratory activities have included any or all of the safety information in the published material. In many cases the authors, publishers, and manufactures assume that the teacher recognizes all of the safety hazards contained within the science activity. The hazards range all the way from common sense considerations, to highly technical information, depending upon the nature of the activity and the materials being used. Machines should not be forced to operate beyond their intended limits in the spirit of scientific discovery.

The teacher must not make the assumption and take it for granted that the students have recognized any or all of the safety hazards and will perform the operation and use the equipment in a safe manner. The teacher should not allow his own over-familiarity with many common machines and tools to interfere with his cautious handling of the equipment.

Learning about the safety limitations in the use of energized equipment and energy sources is part of physical science education.

A. DEGREE OF HAZARDS



Everyone wants to work safely with machines and tools. To do this you must have mature respect for the machinery you are using and its safeguards. The wearing of loose clothing, neckties, watches, rings and other jewelry should be avoided around mechanical equipment. The neglect of proper wearing apparel and safety equipment, or the improper use of the machine can cause serious injury to the appendages, torso and sensory organs.

B. AIR COMPRESSOR SAFETY

1. Introduction

Air compressors are not playthings and must be used in a safe manner. The recommendations that apply to belt guards and mounting instructions also apply for air compressors.

2. Degree of Hazards

There are a number of other precautionary measures which should be followed. Take care to be sure that you are using the proper air line. The fittings and valves are often easily recognized, but sometimes the hose lines cross and can confuse the operator.

Check to be sure the air hose is in good condition. The air hose is designed to withstand pressure, but it will weaken at places where it is bent, where it is attached to shut off valves, and to the nozzle. It will also weaken where it has been kinked. Such weak points may swell like a balloon and burst, throwing pieces of hose in every direction. This may also cause the hose to thrash around dangerously causing serious injury to the eye, ear, or internal body organs.

3. Precautionary Measures for Air Compressors

The following precautions should be used in operating this equipment:

1. Keep air hose off the floor to prevent trip hazard and air line damage.
2. Prevent sharp objects - even hose fittings that have been burred - from rubbing against the hose.
3. Always coil the hose, without kinks, and hang it over a wood board support.
4. Wear safety goggles when using an air line.
5. Use the lowest pressure that will do the job, when you have a choice. There are good reasons for this and here are a few:
    a. Air pressure of 40 lbs. can drive chips and scales from inside the piping into your face and eyes with the force of shrapnel.
    b. Air pressure against the skin may penetrate deeply to cause internal hemorrhaging and pain.
    c. Air pressure, even at 40 lbs., can blow an eye from its socket, or rupture an eardrum.
6. Use vacuum cleaning or brushing to remove dust from clothing. Use a brush to clean tables and working areas.

C. PRESSURE GAUGE SAFETY

1. Introduction

There is some degree of hazard involved in the use of pressure gauges. Operation of these devices beyond manufacturer's recommendations and applicable standards of the American Safety Association may cause the gauge to fail destructively.

2. Degree of Hazards

The failure of a pressure gauge may cause eye injury and internal organ damage from exploding fragments.

3. Precautionary Measures for Pressure Gauges

The American Safety Association recommends that pressure gauges be operated in the following manner:

1. The maximum working pressure of the gauge, under steady pressure should not exceed two thirds (2/3) of the maximum pressure provided on the scale, if accurate indication is to be maintained and long life for the elastic-chamber is to be expected.
2. In case of fluctuating pressure, the maximum working pressure should not exceed one half (1/2) of the maximum pressure provided on the scale.
3. If the above recommendations are exceeded, the elastic-chamber may take a permanent set, thus causing error in pressure indication. In no case should the gauge ever be exposed to a pressure beyond the maximum pressure provided on the scale.
4. Possibly the safest method to use in determining the proper gauge to be utilized for a particular job is to:
   a. Determine the maximum working pressure you intend to use.
   b. Multiply that number by 1.5 and prepare your purchase requisition to specify a gauge with full scale reading equal to or greater than that number.

D. VACUUM PUMP SAFETY

The main hazard in using a vacuum pump is the moving belt. A cover guard is required. The two types of guards commonly used to protect the operator are the fixed guard and the interlocking guard.

Fixed guards are the most commonly used protective devices. The fixed guard protects the operator from dangerous moving pulleys and belts at all times.

Interlocking guards are used when a fixed guard is not practical. This type of guard will not allow the machine to be put into operation until dangerous parts are guarded.

While all pumps and other belt driven equipment presently in use in the laboratory should be equipped with belt guards, it should be noted that sometimes new pumps are not guarded. Because of this, orders for new equipment should specify that pumps are to be equipped with belt guards.

The installation of pumps and belt driven machines on a table or bench, should be designed to secure the apparatus firmly to prevent unintentional movement or tipping. A stationary machine should be anchored or provided with antislip pads to prevent unintentional movement.

The operator should also wear safety glass as an additional precaution from flying belt fragments.

E. HAND TOOL SAFETY

1. Introduction

A surprisingly large number of injuries received in laboratories result from the use of hand tools. Nearly all such accidents are due to personal carelessness - mishandling tools, neglecting to keep them in good working condition, and leaving them about in dangerous places. These are a few of the forms of carelessness that can cause trouble and produce unwanted injury.

2. Degree of Hazard

Varying types of injury to the eyes, hands and limbs can occur when hand tools are improperly used or maintained.

3. Precautionary Measures for:

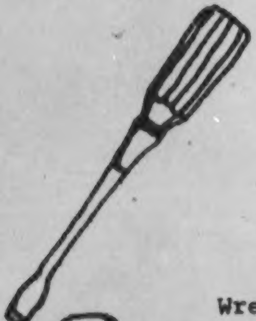
Chisel, Hammers and Punch

1. Tools using wooden handles should be replaced when cracked.
2. Wooden handles of tools should be secured with wedges.
3. Tools with metal striking surfaces should not be used when the ends become mushroomed. The striking end should be ground with a crowned radius and beveled edge.
4. Using a sponge guard on chisel handles will prevent injury to the hand.

Pliers

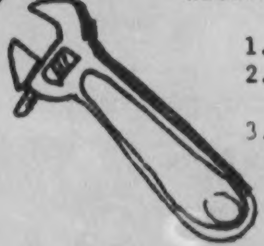
1. Pliers with sprung jaws, a worn face, or worn joint pen should be replaced.

Screwdrivers

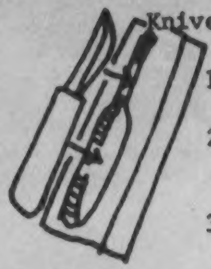


1. Objects being worked on with a screwdriver should not be held in the hand, on the lap, or under the arm, except when protection is afforded by the object, or other means.
2. Screwdrivers should never be carried in pockets.
3. A screwdriver used for electrical work should be equipped with a nonconductive handle.
4. Blade type screwdrivers should be maintained with a flat tip at right angles to the shank and have almost parallel faces.
5. Use the proper size screwdriver for the material being used.
6. A screwdriver that is defective in any manner should not be used.

Wrenches



1. A wrench with spread, distorted, or cracked jaws should not be used.
2. A wrench, except a wrench designed for the purpose, shall not be subjected to hammering.
3. Use a pushing action when using a wrench.



Knives

1. A fixed blade knife should be carried in a sheath, in a tray, or other equivalent protective means.
2. A folding knife which cannot be locked in place should not be used in a manner where the blade could fold on the fingers.
3. When using a knife the cutting stroke should be away from the body when possible. Otherwise, adequate protection should be worn to protect the body, and provisions should be made to hold the material steady.
4. Exposed cutting edges of knives should be covered and stored in their proper place when not in use.

F. PORTABLE POWER TOOL SAFETY

1. Introduction

Portable power tools includes such machines as circular saws, drills and saber saws. These tools probably have as much safety built into them as most tools on the market. In addition, the manufacturers usually provide complete instructions for safe operation of the tools. These factors do not preclude the fact that the safe operation of this type of tool is dependent upon the mature, cautious judgment of the operator. These tools should always be handled with respect while using proper safety precautions.

2. Degree of Hazard

Varying types of injury can result to hands, eyes, and limbs when the tools are improperly maintained or used. The greatest dangers seem to arise from careless use, or from particles of the stock material which are projected from the working area.

3. Precautionary Measures for Power Tools

Machine guards should be properly secured to power saws and inspected regularly for proper operation. The guard should be above and below the base plate. The upper guard shall cover the saw to the depth of the teeth, except for the minimum arc required to permit the base to be tilted for bevel cuts. The lower guard shall cover the saw to the depth of the teeth, except for the minimum arc required to allow proper retraction and contact with the work. The guard should not be removed or tied back except for servicing and when electrically disconnected.

1. A cracked circular saw blade should be removed for service.
2. Safety goggles shall be worn while operating these tools.
3. Hands should be out of the way of the cutting area.
4. Loose clothing and jewelry should be secured in order to prevent snagging or entrapment with the machine.
5. Chock keys should be attached near the plug of the electrical cord.
6. Chocks of drills and saber saws should be cleared and inspected

before loading.

7. The working stock should be securely stabilized while cutting or drilling.
8. The working area should be inspected and cleared before starting an operation with the tool.
9. Electric cords should be properly grounded unless they are double insulated and carry a permanent label or marked so stating. Refer to Electrical Equipment section of this Guide for further information on the safe use of electrical equipment. The symbol of double insulated cords is a square within a square.

References

1. Department of Labor. Occupational Safety Standards Commission.

Safety Standards, Part 1, July 5, 1974
Machine guards and devices R-408.1003

Hand and Portable Powered Tools, Part 38, July 5, 1974

Employee Responsibilities	R-408.13812
General Hand Tools	R-408.13831
Knives	R-408.13840
Pliers	R-408.13841
Portable Circular Saw	R-408.13863
Machine Guards	R-408.10034
Machine Installations	R-408.10031
Small Hand Tools	R-408.13847
Saws and Drills	R-408.13866
Polishing, Buffing and Abrading	R-408.11101

2. Laboratory Safety. Department of Environmental Health and Safety, University of Michigan Health Service.

Vol. 2, No. 10	Grounding Portable Power Tools
Vol. 2, No. 11	Guarding Rotating Mechanisms
Vol. 6, No. 12	Pulley and Belt Guards
Vol. 7, No. 1	A Warning About Pressure Gauges

VIII. ROCKETS AND BALLOONS

REFERENCE PAGE FOR ROCKETS AND BALLOONS

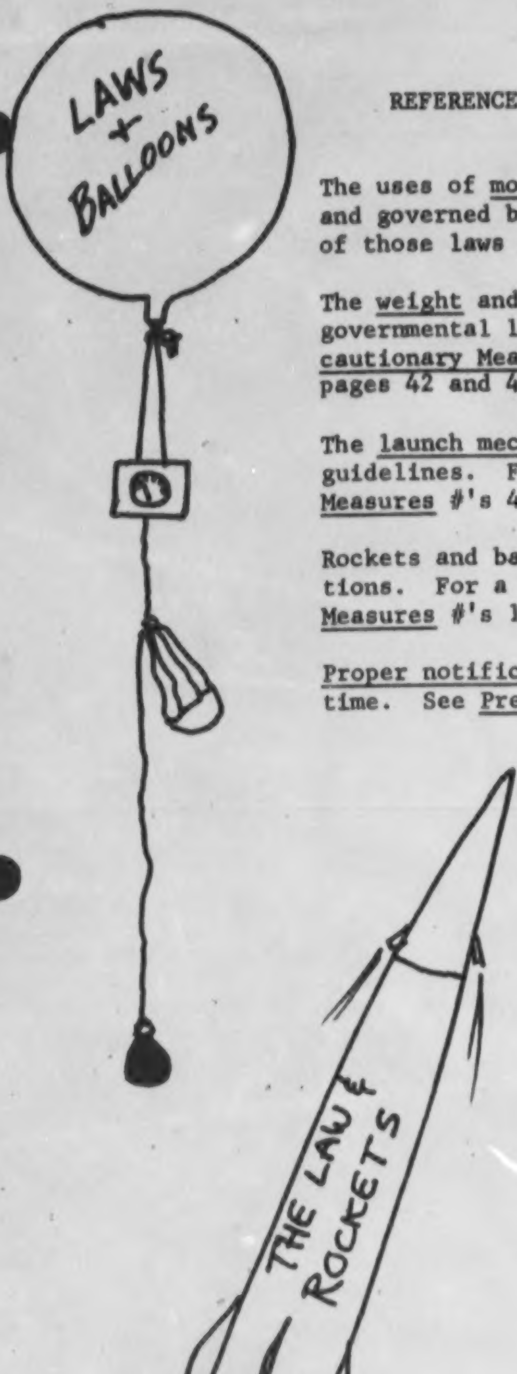
The uses of model rockets and balloons by students are limited and governed by both federal and state law. For the citation of those laws see Appendix D, Federal and State Laws, page 55 .

The weight and construction of the rocket must not exceed governmental limits. For a summary of those limits see Precautionary Measures #'s 1, 2, 3, 5, 6, 7, 8, 9, 10 and 11, pages 42 and 43.

The launch mechanism and launch area must meet governmental guidelines. For a summary of the guidelines see Precautionary Measures #'s 4, 12, 13, 14, 15, 16, and 22, page 43 .

Rockets and balloons can only be launched under limited conditions. For a listing of the conditions see Precautionary Measures #'s 13, 19 and 20, page 43 .

Proper notification must be given to the F.A.A. prior to launch time. See Precautionary Measures #'s 26 and 27, page 44 .



VIII. ROCKETS AND BALLOONS

Introduction

The use of rockets and balloons as a science activity is becoming more popular as the years go by. Many of our students begin the activity as a hobby and continue it beyond the completion of the class project.

This becomes a unique activity because it must be conducted outside of the school room, it involves the safety of the entire area surrounding the school, and is governed rather closely by federal and state law.

The teacher should understand and have experience in all aspects of the project prior to starting the unit with the students.

The rules governing the use of model rockets and free balloons are covered by Volume VI, Part 101 of the Federal Aviation Administration Code and Section 18. 1236 of the Michigan Statutes Annotated.

For the purpose of these acts, a model rocket is any aero model that ascends into the air without the use of aerodynamic lifting forces against gravity and is propelled by means of a model rocket engine. The engine is defined as a device or combination of devices which provide the necessary force or motive power to cause the rocket to move through the air.

This section also contains information on moored balloons, kites, and free balloons.

A. DEGREE OF HAZARDS

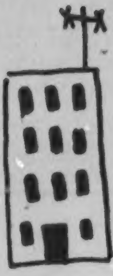
The hazards connected with the use of these objects are centered around the following topics:

1. The design and construction of the rocket.
2. The propulsive force that is used.
3. The flight areas that are available.
4. The launching conditions, areas, and times.
5. Methods of testing the rocket engine.
6. Rocket activities prohibited by law.
7. The safety of the launch area and the flight path.
8. Student experiments with design, construction, and propulsion beyond the limits of the law.
9. The use of free balloons at high altitudes and over large areas.

B. PRECAUTIONARY MEASURES FOR ROCKETS AND BALLOONS

1. The gross weight, including the engine, cannot exceed 16 ounces (453 grams).
2. No more than 4 ounces (113 grams) of propellant materials can be contained in the engine at time of launch.
3. The rocket should be so constructed as to be capable of repeated flights and shall contain means for retarding descent to the ground so that it will not be substantially damaged.

4. The rocket flight should not create a hazard to persons and property on the ground.
5. The rocket should be constructed without substantial metal parts.
6. The design and construction should include attached surfaces which will provide aerodynamic stabilizing and restoring forces necessary to maintain a substantially true and predictable flight path.
7. The rocket cannot contain any type of explosive or pyrotechnic warhead.
8. The engine should be commercially manufactured so that all of its chemical ingredients of a combustible nature are pre-mixed and ready for use.
9. The force or motive of power should be created by a rearward discharge of gas generated by the combustion, or other operation of the materials contained solely within the device.
10. If the engine is constructed with the use of metal it should be equipped with a safety release in the event of a rupture of the engine casing.



11. The engine must be so designed and constructed as to be incapable of spontaneous ignition or combustion: in air, water, under pressure, as a result of motion or jarring, when subjected to a temperature of 170°F or less, or in glycerine.
12. The launch area should contain at least 5000 square yards, be generally rectangular in shape with no side less than 50 yards in length.
13. Flight areas should not contain or be located adjacent to: a high voltage power line, major highways, multi-story buildings, or other obstacles. The rocket cannot be flown into a cloud, or at night.
14. At time of launch a device should be used that will restrict the horizontal motion of the rocket until sufficient flight velocity has been attained for a reasonably safe predictable flight.
15. The launching or igniting of the rocket should be conducted by remote electrical means fully under the control of the person launching the model.
16. The launching angle should be between 60° - 90° from horizontal.
17. An adult should inspect each rocket prior to flight and supervise all launchings.
18. All persons in the area of the launch should be warned that a launching is imminent.
19. At time of launch the wind speed should be less than 20 mph and the visibility should be greater than 2000 ft.
20. The flight of the rocket should not create a hazard to aircraft.
21. Rocket engines may only be ground tested under conditions listed in Section 18.1236(7) of the Michigan Code.
22. The rocket cannot be used within four miles of the boundary of any airport.

23. The rocket cannot be used for pyrotechnic purposes, or for the primary purpose of producing a display of color, sound, light, or any combination of the three.
24. Students should not be allowed to tamper with the engine.
25. Any operation of a moored balloon or kite must comply with the F.A.A. regulations concerning: size, height of flight, flight area. time of flight and visibility of object.
26. Unmanned rockets cannot be launched unless the proper notice has been given to the F.A.A. ATC facility. (See FAA Regulations, Vol. VI, Sec. 101.25).
27. Unmanned free balloons cannot be launched unless they comply with F.A.A. regulations concerning operating limitations and notice requirements. Refer to the copy of the F.A.A. regulations for rules and regulations.

C. HIGH RISK SITUATIONS

The high risk situations in using rockets and balloons are found in the following areas:

1. Unsafe launch conditions.
2. Tampering with the rocket fuel mixture and/or construction.
3. Uncontrolled flight.
4. Launching in improper areas, at improper times, without proper notice to F.A.A.
5. Overloading the rocket payload or fuel quantity.
6. The teacher unaware of the state and federal regulations governing these types of activities.

References:

Moored Balloons, Kites, Unmanned Rockets, and Unmanned Free Balloons, Vol. VI, Part 101. Department of Transportation, Federal Aviation Administration, Washington, D.C. Federal Aviation Regulations governing the use of unmanned rockets and balloons. Information on kites and operating limitations also included.

Model Rockets, Act 333, 1965, Michigan Statutes Annotated Cumulative Supplement, Section 18.1236. Michigan Attorney General Office, Lansing, Michigan.

Why Model Rocketry? (paperback), 1969. Estes Industries, Inc., Penrose, Colorado. Contains the model rocket code for model rocketeers and a description of the development of the model rocket industry since 1957. Booklet is for model rocket.

IX. MISCELLANEOUS

REFERENCE PAGE FOR MISCELLANEOUS

The topics covered in this section are:

- Centrifugal Force Wheel, page 46.
- Combustion Engines, page 46.
- Compressed Gas Cylinders, page 46.
- Density of Air, page 46.
- Dry Ice, page 46.
- Electron Beam Tubes, page 47.
- Engine Pressure, page 47.
- Ether, page 47.
- Induction Coils, page 47.
- Mercury, page 47.
- Microwave Ovens, page 47.
- Pressure Cooker, page 48.
- Radio and TV Equipment, page 48.
- Rotating Disks, page 48.
- Solar Energy Activities, page 48.
- Storage Cells and Lead-Acid Batteries, page 49.

IX. MISCELLANEOUS

Introduction

This chapter will deal with topics not covered in any of the previous sections of this booklet. Each topic contains information on an item that is used in physical science labs and contains within itself a potential hazard to students and teacher.

A. CENTRIFUGAL FORCE WHEEL

A plastic cover should be mounted on the axle near the handles of a centrifugal force or cycle wheel demonstrator. These plexiglas guards will allow the operator to handle the apparatus safely without catching his hands or clothing in the spokes of the spinning wheel.

Loose fitting clothing should not be worn while demonstrating these machines. Sleeves should be rolled up during operation.

B. COMBUSTION ENGINES

The switch should be the last part of the system to be assembled in order to prevent the engine from starting prior to a completed assembly. All moving parts should be labeled. All internal combustion engines should be either operated outside the building, or under conditions where exhaust fumes are vented to the outside.

C. COMPRESSED GAS CYLINDERS

A variety of compressed gases are used in science laboratories. Although they may differ in such characteristics as toxicity and flammability, they are all stored under pressure. The controlled release of a compressed gas is essential in order to protect lives and property. The uncontrolled release of a compressed gas, regardless of the speed of release can create a health and physical hazard. If the cylinder valve is broken off, a high pressure cylinder can become a missile. Therefore, compressed gas cylinders should not be dropped, knocked over, rolled, dragged, or banged against each other. They must be stored, transported and handled in a safe manner. They should not be stored for an indefinite period of time. See References on Laboratory Safety articles dealing with compressed gases, especially Vol. 12, No.'s 9 and 10. This must be done if large size cylinders are being used, or if a large number of cylinders are being stored.

D. DENSITY OF AIR

When density of air experiments are used by evacuating a bulb, the bulb should be wrapped in a towel in order to avoid flying glass in case the bulb should break. A round-bottom flask works better than a flat-bottom flask.

E. DRY ICE

Always handle with tongs or asbestos gloves, NEVER with the bare skin.

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E. DRY ICE

Always handle with tongs or asbestos gloves, NEVER with the bare skin.

Dry ice can cause serious burns to the skin. The work area should be properly ventilated in order to prevent the accumulation of carbon dioxide gas.

F. ELECTRON BEAM TUBES

Certain types of electron beam tubes can generate X-rays. Examples are color T.V. sets, high power Klystron tubes used in radar, cold-cathode gas discharge tubes, Fluorescence Effect Tubes, and Crookes Tubes.

All X-ray equipment should be checked periodically for stray radiation and compliance with state regulations.

G. ENGINE PRESSURE

When demonstrating the buildup of pressure by increasing the heat in a flask, the system must include a safety outlet so that an explosion will not occur.

H. ETHER

Ether is sometimes used in pressure demonstrations. Ether is explosive, therefore it should not be used in the vicinity of flames or sparks. The room must also be properly ventilated.

Disposal time depends upon the type of ether: isoamy, isopropyl, and anhydrous - 6 months. Ethyl and others - one year. Ether should be stored in metal containers, in cool areas, away from the light.

I. INDUCTION COILS

All types of induction coils should be clearly marked for the low voltage and high voltage connections, in order to avoid the possibility of shocks.

J. MERCURY

When using Mercury, especially when making barometers, caution must be used so that the metal not be lost in places where it cannot be picked up. Mercury vaporizes slowly and the vapor is harmful. It can also be absorbed through the skin and is a cellular poison. If Mercury is spilled, precautions must be taken to reduce possibilities of excessive exposure to the vapor. See Laboratory Safety, Vol. 12, No. 4 for a complete discussion of clean up of Mercury spills.

K. MICROWAVE OVENS

These devices are safe, provided correct construction and maintenance measures are adhered to. Federal standards call for ovens to not emit more than 5 mw/cm^2 at a distance of 5 cm throughout their useful lives. Under suitable conditions, microwaves can produce large amounts of heat in living tissue. An individual who is irradiated by microwaves can suffer serious tissue damage without being aware of it.

Precautionary Measures for Use of Microwave Ovens

1. Check door for loose hinges, damaged grid, loose door seals

2. DO NOT put metal objects in oven.
3. DO NOT use oven unless it is clean.
4. DO NOT look through grid while oven is in use.
5. DO NOT come near oven if wearing a pacemaker.
6. Place object in exact center of oven.

L. PRESSURE COOKER

Pressure cookers are to be used for demonstration purposes. They must first be examined to be certain that the safety valves are operating properly. The pressure should not be allowed to go above 20 lbs.

M. RADIO AND TV EQUIPMENT

1. The teacher should be sure that the current is off before allowing students to work inside radios or TVs.
2. Students should allow the instrument to properly cool before work is started on internal parts.
3. There must be a "bleeder" (high resistance) across the output of the power supply in order to protect the student against shock from the charged condenser.
4. When using a tube radio, where the tubes are connected in series and the set works directly from the line, caution must be observed to prevent any grounded metallic object from coming into contact with the metallic chassis.
5. The students must be cautioned in the handling of the high voltages that can be found in standard transformer radios. Severe burns and shocks can result from contacts with radio parts.
6. Caution must be exercised in demonstrating, adjusting, and/or using image tubes from TV sets or cathode-ray oscilloscopes. When the tubes are removed from their protective housing they may implode with great force or produce a high voltage discharge from the rear of the tube.

(Also see previous section on Electron Beam Tubes)

N. ROTATING DISKS

When using any type of wheel, revolving disk, or hoop the teacher must be sure that the safety nut that holds the rotating piece is securely fastened. The apparatus should only be used at moderate speeds. Excessive speeds may cause the disk to shatter.

O. SOLAR ENERGY ACTIVITIES

One of the fastest expanding areas of experimentation and demonstration uses the sun as the direct source of energy. The solar energy device should be handled like any other source of high energy.

Precautionary Measures for Use of Solar Energy

1. Survey students for possible cases of skin sensitivity to sunlight.
2. The design and duration of the activity should not lead to cases of sunburn.
3. Students should be made aware of the high temperatures at the focal point of solar cooking devices.
4. Students should be instructed not to look into the area of concentrated light and/or heat.
5. The cooking device should not be directed on flammable materials.

6. The cooking device should not be used to build up temperatures in a closed container, unless it is part of the experiment.
7. The area of high temperature should not be directed on another individual.

P. STORAGE CELLS AND LEAD-ACID BATTERIES

During the charging of a student storage cell the students should be cautioned against the fine spray that develops. The spray is harmful if it is inhaled and can be harmful if it is allowed to get on the skin. A storage cell or battery is a source of danger even though it only has low voltage because of the acid it contains and because of the very high current which may be drawn from it on a short circuit. Ventilation must be provided when charging lead-acid batteries in order to remove the hydrogen gas that is produced. Sparks and open flames must be kept away from the batteries.

References

1. Laboratory Safety. Department of Environmental Health and Safety, University of Michigan Health Service, Ann Arbor, Michigan.

Vol. 2, No. 1	Mercury Poisoning
Vol. 2, No. 11	How Long Should Ethers Be Stored Removal of Compressed Gas Cylinders from Laboratories
Vol. 3, No. 1	Preventing Lead-Acid Battery Explosions
Vol. 5, No. 6	Cleaning Up Mercury Spills
Vol. 6, No. 12	X-ray Production from Electron Beam Tubes
Vol. 7, No. 11	Compressed Gas Cylinders
Vol. 7, No. 2	Mercury
Vol. 7, No. 12	A Note on Microwave Ovens
Vol. 8, No. 10	Microwave Ovens
Vol. 9, No. 4	Compressed Gas Cylinders
Vol.12, No. 4	Mercury - A Continuing Problem
Vol.12, No. 9	Safe Handling of Compressed Gases
Vol.12, No. 10	Safe Handling of Compressed Gases (cont.)

2. "Battery Charging Safety," No. 46, Safety Education and Training Division, Michigan Deparment of Labor, Lansing, Michigan 1974

3. "Compressed Gases," Occupational Safety Standards Commission, Michigan Department of Labor, Lansing, Michigan, 1975

4. "Inspection of Compressed Gas Cylinders," Occupation Safety Standards Commission, Michigan Department of Labor, Lansing, Michigan, 1975

APPENDICES

Appendix A:

LIABILITY AND TEACHERS

In order for you to be aware of the legal implications that are associated with teaching you should be familiar with the following:

a. Sovereign immunity
b. Criminal negligence
c. Tort laws

In the past in many states the schools were considered to be a subordinate unit of the state government and as such were protected from suits in cases of bodily injury which resulted from the negligence of an employee under what was known as Sovereign Immunity. Simply stated it meant that you couldn't sue the King or the state. Some teachers who have heard of sovereign immunity have had the mistaken idea that they were also protected from suit, this is not the case. In fact in recent years in Michigan school boards and board members have found that the idea of sovereign immunity is no longer accepted by the courts. School boards and teacher associations now carry insurance to provide some protection for their employees.

Criminal negligence involves committing a crime against society which may involve injury or death to another individual. In a case of criminal negligence the individual is already committing a crime when the injury or death occurs which in itself would subject him to arrest, trial, and imprisonment. An example might be a teacher driving a school bus full of students on a field trip while under the influence of alcohol or drugs.

In a school accident a teacher may not be charged under criminal negligence and yet be taken to court in a tort lawsuit. Whereas in the criminal negligence a crime is committed against society; in committing a tort one may break the law against an individual. A tort is defined as a civil wrong committed against another person. There are four elements which must be shown if a person is to be held liable in a tort lawsuit. They are:

1. "Duty" All people owe all other people the duty of not infringing on their right to be free from physical and mental injury. As a teacher you then should know what your duty is in relation to your students.

2. "Violation or Breach of Duty" When an individual has infringed upon another's rights he has violated or committee a breach of duty.

3. "Cause or Proximate Cause" If a student is injured and the injury might have been prevented by you the teacher performing your job in a reasonable manner, then you could be the "proximate cause" for that injury.

4. "Injury" In the case of a student, the infringement of the individual's rights by you as the teacher results in the student being injured either physically or mentally.

One key factor in such suits is the idea of reasonableness. If the teacher acts in a manner that could be expected by any other teacher in a similar situation then he is not guilty of a tort violation.

Gatti offers these guide rules for teachers in considering liability and teacher responsibilities under the law:

GUIDE RULE — BEING A TEACHER MAKES YOU RESPONSIBLE FOR YOUR STUDENTS' INSTRUCTION, SUPERVISION AND SAFETY. IF YOU DO NOT FULFILL THIS RESPONSIBILITY, YOU MAY BE HELD LIABLE.[1]

You can be held liable for anything that you have done which is improper or wrong. The key to your actions is "reasonableness". Gatti in describing negligence explains it in terms of reasonableness as follows:

> Negligence is: not doing something which the reasonable teacher, considering the circumstances, would ordinarily do; or doing something which the ordinary teacher of reason and prudence would not do.[2]

He further offers these rules concerning negligence and reasonableness:

GUIDE RULE — NEGLIGENCE EXISTS WHERE THE ACTIVITY OR CONDUCT ON THE PART OF THE TEACHER CREATES AN UNREASONABLE CHANCE OF DANGER. WHEN THE TEACHER IGNORES THE DANGER, OR DOES NOT SEE THE DANGER WHEN HE SHOULD,[3] HE MAY BE HELD NEGLIGENT IF SOMEONE IS INJURED AS A RESULT.

GUIDE RULE — DID THE ACT WHICH CAUSED THE INJURY EXCEED REASONABLE LIMITS, TO THE POINT WHERE THE TEACHER WAS NOT ACTING WITHIN THE RIGHTS OF HIS EMPLOYMENT? IF SO, HE IS RESPONSIBLE.[4]

Gatti also states that a teacher should not only have safety rules for the students to follow in the class but the teacher should also see that the rules are enforced.

GUIDE RULE — IF A RULE IS BROKEN, STEPS MUST BE TAKEN TO ASSURE THAT THE INFRACTION WILL NOT OCCUR A SECOND TIME. IF A TEACHER DOES NOT TAKE FURTHER STEPS, HE MIGHT BE FOUND LIABLE ON THE GROUNDS THAT THE RULE DID NOT REALLY EXIST, EXCEPT ON PAPER.[5]

Along with reasonableness the idea of forseeability is important in determining if a teacher has acted in a responsible manner. Gatti offers the following rule on forseeability:

GUIDE RULE — INJURY IS GENERALLY FORESEEABLE IN SITUATIONS (1) WHERE LARGE CROWDS OF STUDENTS ARE GATHERED WITHOUT SUPERVISION; (2) IN SPECIALIZED ACTIVITIES IN VOCATIONAL EDUCATION, PHYSICAL EDUCATION AND SCIENCE CLASSES; OR (3) IN CASES WHERE YOU ARE ABSENT FROM THE ROOM FOR AN UNREASONABLE AMOUNT OF TIME.[6]

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[1] Gatti, Daniel Jon. The Teacher and the Law. West Nyack, New York. Parker Publishing Co., Inc. 1972. Page 19.
[2] Ibid. Page 52.
[3] Ibid. Page 52.
[4] Ibid. Page 22.
[5] Ibid. Page 57.
[6] Ibid. Page 62.

Appendix B:

MICHIGAN OCCUPATIONAL SAFETY & HEALTH

Act 154 of P.A. 1974

Department's Authority

Make inspections of work places based upon employee complaints concerning alleged hazardous working conditions.

Conduct unscheduled inspections at reasonable times and in a reasonable manner of all places of employment in order to physically inspect work areas for compliance with safety standards.

Advise an employer that an imminent danger exists and issue administrative orders requiring that steps be taken which are necessary to avoid, correct, or remove the imminent danger.

Issue citations and proposed penalties to any employer for failure to comply with standards, rules, orders or provisions of this Act.

Issue cease operations orders when an employer fails to comply with a final order of the Board.

Employer's Responsibilities

Furnish and maintain a work environment which is free from recognized hazards that are causing or likely to cause death or serious physical harm.

Comply with specific Occupational Safety and Health Standards that apply to working conditions in their establishments.

Post notices and use other required or appropriate means of informing employees of their protections and obligations under the Act.

Post all citation appeal decisions in the same manner as citations so as to inform employees.

Employee's Responsibilities

Comply with all applicable Occupational Safety and Health Standards established under the Act.

Refrain from removing, displacing, damaging, destroying, or carrying off a safeguard furnished or provided for use in a place of employment or interfering in any way with the use thereof by any other person.

81

Employee's Rights

Entitled to work in a place of employment free from recognized hazards that are causing or are likely to cause death or serious physical harm.

May file a written request with the Department for an inspection where it is believed that a violation of a standard exists. Entitled to have identity withheld and to receiv a written reply of Department findings.

May request an immediate inspection when an alleged imminent danger exists.

Authorized employee representative is entitled to accompany the Department representativ during an inspection or investigation.

Authorized employee representative is entitled to a conference with the departmental representative to review findings upon completion of an inspection or investigation.

Entitled to know that a citation was issued by the Department through the posting of such citation near the place of violation.

Entitled to receive medical tests or examinations when required by a standard.

Entitled to be apprised by employer of a health hazard to which he or she is exposed when the hazard is covered by a standard.

Entitled to protection against being discharged or otherwise discriminated against for filing a complaint or instituting a proceeding under this Act.

NOTE: Where employees select a person to represent them, employee rights may be exercised by the "authorized employee representative" as provided in the Act.

For further information contact:

Michigan Department of Labor
Bureau of Safety & Regulation
7150 Harris Drive
Lansing, MI 48926
General Industry Division (517) 37-39620
Construction Safety Division (517) 37-39634
Safety Education & Training (517) 37-39160

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Appendix C:

HANDICAPPED STUDENTS

Some special precautions should be taken for the safety of handicapped students. The following are some guidelines.

1. The work area should be low enough to allow a student in a wheelchair to work safely. It should be constructed so that spills onto the student are prevented.

2. Whenever possible, ramps, as well as stairways, should be provided for students in wheelchairs.

3. Students in wheelchairs should be assigned work areas near exits and non-handicapped laboratory partners.

4. Students who have hearing or vision handicaps should be assigned responsible laboratory partners who are without handicaps.

5. Students who have unusual emotional, or behavioral problems should be identified at the start of the semester and be carefully monitored when using dangerous, or expensive equipment. They should be removed from the classroom when their behavior could cause a hazard to themselves or other students.

Appendix D:

FEDERAL AND STATE LAWS

1. Rocket and Missile Launching, Federal Aviation Regulation Part 101. Governs the size, type, construction, and launching considerations of model rockets. Minimum size rockets that would fall under control of this regulation would be illegal in Michigan, as they would exceed maximum allowable specification under Michigan's Model Rocket Law.

2. Michigan Model Rocket Law, Act. 333, P.A. 1965, Michigan Statutes Annotated of 1965 (18,1236).
   Specifies the size, type, construction, testing, and launching requirements for model rockets.

3. Registration of Labs Handling Pathogenic Micro Organisms, Act. 308, P.A. 1927, Michigan Department of Public Health, 3500 N. Logan Street, Lansing, Michigan. Requires the registration of all laboratory facilities utilizing pathogenic micro organisms.

4. Registration of Labs for the Human Use of Animals, Act. 241, P.A. 1947, Michigan Department of Public Health, 3500 N. Logan Street, Lansing, Michigan. Requires the registration of each individual laboratory facility utilizing animals for experimental purposes. It should be noted that keeping animals for the purpose of observing their natural growth and development would not require registration.

   340.365-As part of the curriculum, every public school teacher in Michigan shall teach kindness and justice to, and humane treatment and protection of animals and birds.

5. Registration for all sources of Ionizing Radiation, Act. 88, P.A. 1943, Michigan Department of Public Health, 3500 N. Logan Street, Lansing, Michigan. Requires the registration of all sources of ionizing radiation, regardless of level. This would include radioactive isotopes and materials, X-ray machines, and cathode ray tubes (i.e. black lights, shadow tubes, etc.). Any time high voltages lead to high speed particles being produced, registration may be necessary.

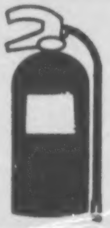
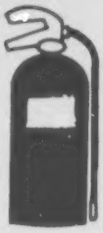
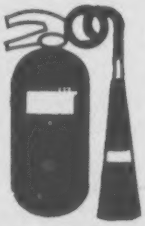
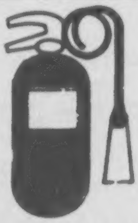
6. School Fire Safety Regulations, Act. 207, P.A. 1941, Fire Marshal Division, Michigan State Police, 416 Frandor Avenue, Lansing, Michigan.
   Governs the design, construction, and operation of school facilities with respect to fire safety. Chemical storage requirements are a part of this act.

7. Occupational Safety, Act. 282, P.A. 1967, Michigan Department of Labor, 300 E. Michigan Avenue, Lansing, Michigan.
   Mandatory safety standards are promulgated under this act that affect all areas of the school facility. Standards requiring the guarding of power transmission equipment, floor and wall openings and stairways, and eye and face protection are but a few. Complete sets of current standards may be obtained from the Occupational Safety Standards Commission, Michigan Department of Labor.

8. Act No. 54 of the Public Acts of 1972 Requires students, teachers, and visitors to wear industrial quality eye protective devices when exposure to danger exists. Eye protective devices must be sanitized prior to use. The law lists a wide variety of potentially dangerous situations in which glasses should be worn.

Appendix E:

KNOW YOUR
FIRE EXTINGUISHERS

	WATER TYPE	A	Ordinary Combustible Fires
	DRY CHEMICAL	B	Flammable Liquid Fires (Gas and Grease)
	CO^2 TYPE (Plastic Horn Only)	C	Electrical Equipment Fires
	MULTI PURPOSE DRY CHEMICAL TYPE	A B C	For Ordinary Combustible Fires Flammable Liquid Fires Electrical Equipment Fires
	DRY POWDER TYPE	D	For Combustible Metal Fires (These Metals In Finely Divided Form Need Special Fire Attack)

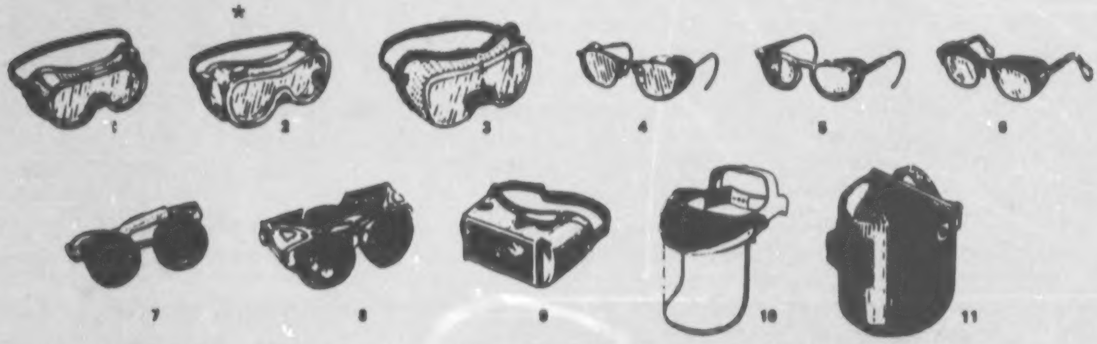
USE ONLY UNDERWRITERS APPROVED EXTINGUISHERS

Appendix F:

USA STANDARD PRACTICE FOR OCCUPATIONAL

Selection Chart

Recommended Eye and Face Protectors for Use in Industry, Schools, and Colleges



1. **GOGGLES,** Flexible Fitting, Regular Ventilation
2. **GOGGLES,** Flexible Fitting, Hooded Ventilation
3. **GOGGLES,** Cushioned Fitting, Rigid Body

*4. **SPECTACLES,** Metal Frame, with Sideshields
*5. **SPECTACLES,** Plastic Frame, with Sideshields
*6. **SPECTACLES,** Metal-Plastic Frame, with Sideshields
** 7. **WELDING GOGGLES,** Eyecup Type, Tinted Lenses (Illustrated)
7A. **CHIPPING GOGGLES,** Eyecup Type, Clear Safety Lenses (Not Illustrated)
** 8. **WELDING GOGGLES,** Coverspec Type Tinted Lenses (Illustrated)
8A. **CHIPPING GOGGLES,** Coverspec Type, Clear Safety Lenses (Not Illustrated)
** 9. **WELDING GOGGLES,** Coverspec Type, Tinted Plate Lens
10. **FACE SHIELD** (Available with Plastic or Mesh Window)
11. **WELDING HELMETS

*Non-sideshield spectacles are available for limited hazard use requiring only frontal protection.
**See appendix chart "Selection of Shade Numbers for Welding Filters."

APPLICATIONS

OPERATION	HAZARDS	RECOMMENDED PROTECTORS: Bold Type Numbers Signify Preferred Protection
ACETYLENE—BURNING ACETYLENE—CUTTING ACETYLENE—WELDING	SPARKS, HARMFUL RAYS, MOLTEN METAL, FLYING PARTICLES	7, 8, 9
CHEMICAL HANDLING	SPLASH, ACID BURNS, FUMES	2, 10 (For severe exposure add 10 over 2)
CHIPPING	FLYING PARTICLES	1, 3, 4, 5, 6, 7A, 8A
ELECTRIC (ARC) WELDING	SPARKS, INTENSE RAYS, MOLTEN METAL	11 (11 in combination with 4, 5, 6, in tinted lenses, advisable)
FURNACE OPERATIONS	GLARE, HEAT, MOLTEN METAL	7, 8, 9 (For severe exposure add 10)
GRINDING—LIGHT	FLYING PARTICLES	1, 3, 4, 5, 6, 10
GRINDING—HEAVY	FLYING PARTICLES	1, 3, 7A, 8A (For severe exposure add 10)
* LABORATORY	CHEMICAL SPLASH, GLASS BREAKAGE	2 (10 when in combination with 4, 5, 6)
MACHINING	FLYING PARTICLES	1, 3, 4, 5, 6, 10
MOLTEN METALS	HEAT, GLARE, SPARKS, SPLASH	7, 8 (10 in combination with 4, 5, 6, in tinted lenses)
SPOT WELDING	FLYING PARTICLES, SPARKS	1, 3, 4, 5, 6, 10
Foundryman's	Dust, Flying Particles	7 & 8 except it is padded

Appendix G:

Laboratory Activities with Radiation and Radioactive Materials

1. As radioactive materials are received, mark them as "RADIOACTIVE" and, if possible, give some indication of the level of radioactivity for that date.
2. Store radioactive materials in a locked cabinet that is clearly marked "RADIOACTIVE MATERIAL."
3. Avoid getting radioactive isotopes near the mouth, eyes, or open sores.
4. No eating, drinking, or use of cosmetics in the area.
5. Do not pipette radioactive solutions by mouth.
6. Avoid inhalation of fumes from reactions involving radioactive materials. Such reactions should be carried out under ventilating hoods.
7. Avoid contamination of the hands. Use tongs or tweezers to handle solid specimens and plastic or rubber gloves for solutions. Wash hands after each experiment and test with a Geiger Counter. Contamination can be removed by scrubbing with a soft brush and soap for several minutes.
8. Spread waterproof paper over working area to simplify "clean-up."
9. Avoid spilling solutions or dropping specimens. If this does happen, check to see that some contamination does not remain.
10. Check area with Geiger Counter after clean-up.
11. If a student should bring a radioactive specimen to the classroom or laboratory, check its level of activity to be certain that it is not dangerously high.
12. Disposal of small amounts of low activity isotopes (in the microcurie range) can be handled safely as follows:
    a. solutions may be diluted with large amounts of water and flushed down the drain.
    b. solid materials and trash may be incinerated without danger, if they are of low activity; however, the materials should be checked to see that the activity is in the microcurie range.
    c. consult Atomic Energy Directives for disposal instructions of more active specimens.

Further information may be obtained from: The National Council on Radiation Protection and Measurements, P.O. Box 4867, Washington, D.C. 20008.

Science Advisory Committee
Curriculum Division
Michigan Department of Education
Lansing, Michigan 48902

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Michigan Department of Labor
300 East Michigan Avenue
Lansing, Michigan 48926

Appendix H:

Safety Rules for a Laser Laboratory

1. Always discharge the laser beam into a background that is non-reflecting and fire-resistant.
2. Design the laser setups to avoid accidental pulsing of the laser and to minimize the possibility of electrical shocks from storage capacitors, power supplies, and other equipment.
3. Keep laboratory personnel a reasonable distance away from ALL SIDES of the anticipated path of the laser beam.
4. Keep the level of general illumination high in areas where lasers are operated. Darkened rooms cause the pupils of the eyes to dilate, and thus increase the amount of energy that may inadvertently enter the eye.
5. Do not count on goggles or safety glasses to protect your eyes. No glasses that are now available offer protection from all wavelengths emitted by existing lasers.
6. NEVER LOOK INTO THE PRIMARY BEAM. Avoid looking at specular reflections of the beam, including those from the lens surface.
7. Never look directly at the pump source.
8. Never aim the laser with the eye. Looking along the axis of the laser beam increases the hazard from reflections.
9. Be especially cautious around lasers that operate in the infrared. These beams are invisible to the human eye. They can consequently cause many small lesions in the eye without the victim's being aware that damage has occurred until the loss of sight becomes noticeable.
10. Do not let the laser beam strike exposed skin surfaces.
11. Anyone who is working in laser test procedures, and anyone who may be frequently exposed to laser discharges, should have thorough general ophthalmological examinations at regular intervals. These examinations should include funduscopic studies and mapping of visual fields.

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Appendix I:

SAFETY TALK: "ELECTRIC SHOCK"

First of all, never stand on wet or damp surfaces when using electric tools.

There are several precautions against accidental grounding that we all should observe when using portable electric tools. Check your tools for these conditions:

- Defective or broken insulation.
- Improper or poorly made connections to terminals.
- Broken or otherwise defective plugs.
- Loose or broken switches.
- Sparking brushes.

If any of these conditions exist, have the tool repaired before using it. Don't use a defective tool.

A couple of other safety rules are important, too. Do not attempt to repair or adjust portable electric tools while they're plugged in. Don't use portable electric tools in the presence of flammable vapors or gases, unless designed for such use.

There's a lot about electricity that's misunderstood and seems to be mysterious. I'm not going to even attempt to cover all of these points. Let me just say that electricity has become an intricate part of all our lives. It's a valuable friend but it must be respected and used wisely the same as a hunting rifle or an automobile.

Some people believe that low voltage shocks can't harm them. Actually, these low voltage jolts can be fatal. The severity of a shock is measured by three factors--the quantity of current flowing through the body; the path of the current as it passes through the body; and the duration of the current.

If faulty tools can be responsible for an accidental grounding, then, naturally tools should receive proper care. They should always be returned to their proper place and should be handled with care.

To reduce the hazard of electric shock, third-wire grounding or approved double-insulated tools are used. The extension cords you use should have three-pronged plugs. Certainly these approved types of accessories should be used at home as well as at work.

There are three factors involved in accidental grounding mishaps which should be recognized. All of these factors are contributed by people. They are: lack of knowledge of safety precautions; ignoring hazards; and neglect.

Again, we will call to your attention that it's important to check your tools before using them. If they appear to be broken, defective or in poor condition, report them. Don't use the tool until it has been approved for further use.

Portable electric tool safety is just one phase of an overall safety program, but it's an important one.

Safety Education and Training Division
Michigan Department of Labor
Lansing, Michigan

Appendix J:

SAFETY TALK: "EXTENSION CORD SAFETY" *

If you leave an extension cord on the floor long enough, one of several things will happen to it. It's either going to be stolen, tripped over or damaged.

Extension cords are designed to be conveniences, not hazards. But too often they're converted into hazards by the people who use them. So for a few minutes let's go over some of the ways these safety hazards are formed.

Extension cords are often placed in areas where people aren't used to having them around and a tripping hazard results. This type of hazard is one of the more common ones; so when you use an extension cord, try to keep it out of aisles and other places where pedestrians might trip over it.

Sometimes the tripping hazard can be eliminated by hanging the cord overhead. Ample clearance should be allowed. However, the fasteners used should be a type that won't damage the cord. Or if the cord is on the floor, a board can be placed on each side of the cord to protect it.

When someone trips over a cord, there's not only a chance of injury but the plug may be jerked to the extent that it's damaged, making it an electrical hazard.

Many hazards can be eliminated to start with by selecting the right extension cord for the job.

All cords should be "UL Approved" and meet electrical code specifications. If you're using portable electrical equipment, the equipment should be properly grounded, and green-covered ground conductor should be used with a polarized plug and receptacle. If polarized receptacles aren't available, third-wire grounding should be used. The wire should be taped at intervals along the cord to avoid a tripping hazard.

Extension lamp cords are items that get considerable usage. Usually these cords are on automatic take-up reels which ease movements and prevent kinking and excessive bending of the cord.

Jacketed cords should be used with portable electric tools or extension lamps to be used in boilers, tanks and other grounded enclosures.

It should also be noted that extension lamps are sometimes used under conditions where a 120-volt shock could be fatal, so cords should always be kept in excellent condition.

Extension lamps with brass shell sockets should not be used. Porcelain, composition or rubber sockets are recommended. Handles of portable lamps should be made of non-conductive material, and there should be no metallic connection between the lamp guard and socket shell.

Plastic covers of some type are recommended for extension cords which are used around solvents or oils. Be careful not to twist or kink cords and always protect them from sharp objects.

If moisture, heat or chemicals are present, be sure your cord is the proper type to resist the conditions there.

A word of caution. If you make a good connection with a live wire, carrying even 110 volts, it can be fatal. Wet or sweaty hands make a dangerous connection when at the same time they are in contact with a good ground like a wet floor, a steam or water pipe, or another electrical connection.

Actually, a lot of the strains on current-carrying parts of extension cords can be prevented by use of heavy-duty plugs which are clamped to the cord. This is particularly helpful in cases where the cord is accidentally pulled or jerked.

You've probably noticed that several times I've mentioned the dangers of pulling and jerking on cords. This is the type of torture that they often receive but aren't built for. That's why it's important to inspect extension cords often, and if they're damaged, don't use them.

Not too many of us qualify as electricians with enough know-how to wire a building safely. Yet, we all become instant electricians of some sort when we use extension cords. We plug them in all over the place and we connect them to anything we want to, often overloading electrical circuits.

So try to remember what extension cords really are. They're a convenience designed for a specific purpose. Handle them with care and use them safely. They aren't the answer to every electrical need, but they're a lot of help when used correctly.

* Safety Education and Training Division
Michigan Department of Labor
Lansing, Michigan

Appendix K:

SAFETY TALK: "HEARING SAFETY" *

Noise is unwanted sound. It can have different effects on you.

Psychological effects mean that noise can startle you, annoy you, and disrupt your concentration.

Noise can interfere with your communications when you are talking to someone. As a consequence it interferes with your job performance and your safety.

Physiological effects mean that you can lose your hearing because of noise; you can experience pain and even nausea when the exposure is severe.

Ear protectors, in effect, reduce noise levels at the inner ear. Ear protection is particularly important when noise-exposures cannot be controlled adequately by environmental changes.

Ear protectors may be either ear plugs or ear muffs.

Many times workers resist wearing hearing protection more than any other type of personal equipment. One of the most common reasons that they give is that they don't think they really need it. But hearing loss is so gradual, even in intense exposures, that by the time you realize that you can't hear as well as you used to, the damage has been done and can't be reversed.

Another common reason workers give for not wearing hearing protectors is that they are uncomfortable. Evidence of this attitude can be found in such practices as "springing muffs" so they don't seal against the head, clipping off the inner end of plugs and leaving only the outer end tab to fool the supervisor, and indifferent molding and insertion of malleable-type plug materials.

Good protection depends on a good seal between the surface of the skin and the surface of the ear protector. A very small leak can destroy the effectiveness of the protection. Protectors have a tendency to work loose as a result of talking, chewing, etc., and they must be reseated from time to time during the work day.

Some initial discomfort is sometimes experienced in obtaining a good seal.

There will be no adverse reactions as a result of the use of ear protectors if they are kept reasonably clean. Ear plugs should be made of soft material such as neophrene, as hard fixed material can injure the canal. Skin irritations, injured ear drums, or other harmful reactions, are exceedingly rare. A properly designed, well-fitted and clear ear protector will cause no more difficulty than a pair of safety goggles.

The use of ear protection will not make it more difficult to understand speech or to hear warning signals when worn in a noisy environment.

Most of the available ear protectors, when correctly fitted provide about the same amount of protection. The best ear protector, therefore, is the one that you can wear properly.

Three factors may be used to determine the level of noise:

1. If it is necessary for you to speak in a very loud voice or shout directly into the ear of a person in order to be understood, it is likely that the exposure limit for noise is being exceeded.

2. If you have head noises and ringing noises in your ears at the end of the work day, you are being exposed to too much noise.

3. If speech or music sounds muffled to you after leaving work but sounds fairly clear in the morning when you return to work, there is no doubt about your being exposed to noise levels that can eventually cause a partial loss of hearing that can be permanent.

If any of these conditions exist, a safety professional using a sound level meter should measure the noise level at various work areas. He can then determine whether the exposure is great enough to require personal protection.

* Safety Education and Training Division
Michigan Department of Labor
Lansing, Michigan

Appendix L:

THRESHOLD LIMIT VALUES *

Federal and State regulations have brought about increased interest in the "Threshold Limit Values for Chemical Substances and Physical Agents." Threshold Limit Values (TLV's) are established by a committee of the American Conference of Governmental Hygienists and are based on information from industrial experiments and experimental human and animal studies.

The Threshold Limit Values are contaminant levels and levels of certain physical agents to which persons may be exposed for specific periods of time, repeatedly, without adverse effects. However, experimenters should be aware that certain people may be hypersusceptible to specific chemicals and physical agents and may experience discomfort or unfavorable reaction to exposures smaller than the TLV's established.

The physical agents for which TLV's have been extablished are: heat stress, ionizing radiation, lasers, microwaves, noise, ultraviolet radiation, and microwave radiation (from 100 GH_2 to 300 GH_2). Magnetic fields, laser radiation - UV radiation for pulsed exposures and infrared-A laser exposures, and ultrasonic energy are under consideration.

The TLV's for ionizing radiation recognized by the American Conference of Industrial Hygienists are the same as those established by the National Committee on Radiation Protection.

Persons who work with lasers should be familiar with the Threshold Limit Values for exposure to laser radiation. The permissible exposure durations vary according to eye exposure, skin exposure, diffuse reflection and wavelength, among others.

With the coming of microwave ovens much public interest has developed in microwaves. The TLV's established for microwave energy are in the 100MHz to 100 GHz frequency range. With microwaves, for average power density levels up to but not exceeding 10 milliwatts/cm^2, total exposure is limited to the 8-hour work day. This is a continual exposure. For power density levels from 10 milliwatts/cm^2, up to but not exceeding 25mw/cm^2 total exposure is limited to no more than 10 minutes for any 60-minute period during an 8-hour work day. No exposure is permitted if the average power density level exceeds 25mw/cm^2.

Ultraviolet radiation TLV's deal with UV radiation in the spectral region between 200 and 400 nm, and apply to eye or skin exposure from various sources (excluding UV lasers). Photosensitive persons may find the TLV's too high for adequate protection. Ultraviolet TLV's vary according to wavelength and relative spectral effectiveness.

For the most part Threshold Limit Values are guidelines. Their application by an untrained person can lead to false conclusions or misinterpretations of actual working conditions. However, all experimenters and teachers should be familiar with the existence and nature of the Threshold Limit Values. Experimenters who wish to become more familiar with the TLV's should contact the Department of Occupational Safety and Environmental Health for a copy.

* Laboratory Safety. Vol. 13, No. 2. Department of Environmental Health and Safety, University of Michigan Health Service, Ann Arbor, Michigan

Appendix M:

UNITED STATES ATOMIC ENERGY COMMISSION GUIDE FOR DRAFTING RADIATION SAFETY INSTRUCTIONS FOR LABORATORY USE OF RADIOISOTOPES *

1. Outline control procedures for obtaining permission to use radioactive materials at the institution; give limitations on quantity to be handled per student or allowed per experiment, etc.
2. Explain what laboratory apparel to wear and what equipment to use.
3. Prescribe limitations and conditions relative to handling liquid or loose radioactive materials and what laboratory equipment to use in working with them. For example, explain when materials and what operations should be confined to radiochemical fume hoods or gloveboxes. Explain what shielding or remote handling equipment is to be used when hard beta and/or gamma emitting materials are handled.
4. Outline routine survey and monitoring procedures to be followed for contamination control.
5. Emergency procedures should include instructions concerning spills, fires, release of material, and/or accidental contamination of personnel. Outline decontamination procedures to use and whom to contact in case of emergencies.
6. Give instructions concerning movement of materials between rooms, halls, or in corridors, if applicable.
7. Explain requirements for storage of materials, labeling of containers, and identification of areas where radioactive materials are used. Explain where and how contaminated articles and glassware are to be handled and stored.
8. Name personnel monitoring devices to use, where to obtain them, and give instructions on recording exposure results.
9. Indicate waste disposal procedures to follow and give limitations for disposal of liquid or solid wastes and procedures to use for waste storage. If program involves experiments in animals, outline instructions on cleaning animal quarters and handling animal excreta and carcasses for disposal.
10. Explain what records are to be kept on materials used and disposed.

* Instructional Aid: How to Handle Radioisotopes Safely, National Science Teachers Association, Washington, D.C.

Appendix L:

THRESHOLD LIMIT VALUES *

Federal and State regulations have brought about increased interest in the "Threshold Limit Values for Chemical Substances and Physical Agents." Threshold Limit Values (TLV's) are established by a committee of the American Conference of Governmental Hygienists and are based on information from industrial experiments and experimental human and animal studies.

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The physical agents for which TLV's have been extablished are: heat stress, ionizing radiation, lasers, microwaves, noise, ultraviolet radiation, and microwave radiation (from 100 GH_2 to 300 GH_2). Magnetic fields, laser radiation - UV radiation for pulsed exposures and infrared-A laser exposures, and ultrasonic energy are under consideration.

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4. Outline routine survey and monitoring procedures to be followed for contamination control.

5. Emergency procedures should include instructions concerning spills, fires, release of material, and/or accidental contamination of personnel. Outline decontamination procedures to use and whom to contact in case of emergencies.

6. Give instructions concerning movement of materials between rooms, halls, or in corridors, if applicable.

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8. Name personnel monitoring devices to use, where to obtain them, and give instructions on recording exposure results.

9. Indicate waste disposal procedures to follow and give limitations for disposal of liquid or solid wastes and procedures to use for waste storage. If program involves experiments in animals, outline instructions on cleaning animal quarters and handling animal excreta and carcasses for disposal.

10. Explain what records are to be kept on materials used and disposed.

* Instructional Aid: How to Handle Radioisotopes Safely, National Science Teachers Association, Washington, D.C.

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Appendix N:

SAFETY TALK: "COMPRESSED AIR" *

Air pollution is very much the concern of everyone these days. But there are dangers other than pollution which involve air.

Compressed air is no plaything and must be used in a safe manner. So before grabbing an air hose and going into action, there are a number of safety guidelines which should be followed.

First of all, be sure that it's an air line you have, not gas or water. Fittings and valves look different, but sometimes hose lines cross and you could be fooled. Take time to make sure each time you use compressed air.

Next, check to be sure the air hose is in good condition. Air hose is designed to withstand pressure, but it becomes weakened at the places where it is bent, where it is attached to the shut off valve and to the nozzle and wherever it has been kinked. Such weak points may swell like a balloon and burst, throwing pieces of hose in every direction. This may also cause the hose to thrash about dangerously. These precautions should be followed:

1. Keep air hose off the floor where it is a trip hazard and subject to damage by trucks, doors, and dropped tools.
2. Prevent sharp objects--even hose fittings that have been burred--from rubbing against the hose.
3. Always coil the hose--without kinks--and hang it over a broad support, not over a hook, nail, or angle iron, when not in use.

Where you have choice of pressure, use the lowest pressure that will do the job. There are many good reasons for this and here are a few:

1. Air pressure of 40 lbs. can drive chips, as well as scale from inside the piping, into your face and eyes with the force of shrapnel. Such air driven missiles still do damage when they bounce off a surface, spinning much like a high speed cutting head.
2. Air pressure against the skin may penetrate deeply to cause internal hemorrhage and intense pain.
3. Air that enters body openings can burst internal organs and cause lingering death in agony.
4. Air, even at 40 lbs., can blow an eye from its socket, rupture an eardrum.

Certainly no one would intentionally cause such injuries. Yet every so often someone does, either accidentally or in ignorance, thinking it's a joke.

The nozzle of an air hose is a deadly weapon. Don't point it at anyone, not even yourself. Use safer, better ways of cleaning dust from your clothes--by vacuum cleaning or brushing. Dust blown from anything merely rises a little and then settles again to become a nuisance. Some of the dust blown into the air ends up on our lungs, and that's not where we want it.

In a few cases, standard safe procedures are set up for trained employees using equipment with known safety factors and observing approved safe practices. These include the following instances:

1. Removing dust or particles from jigs, fixtures, deep holes in parts.
2. Use low pressure, 30 lbs. or less, and the right nozzle.
3. Wear cup-type goggles and set up shields to protect passers-by and others in the area.

For transferring liquids from properly rated pressure vessels, check air pressure, attach hose connection tightly, remain at control valve to shut off in emergency, and make sure bleed-off valve and pressure relief valve work. NEVER use compressed air to transfer flammable liquids.

By now the message should be clear--compressed air must be treated with respect. It's a valuable tool but it must be used intelligently and in a safe manner.

* Safety Education and Training Division
Michigan Department of Labor
Lansing, Michigan

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Appendix O:

GROUNDING PORTABLE POWER TOOLS *

Numerous laboratories maintain portable electric power tools such as drills, saws, and grinders. While the possibility of mechanical injury when using such equipment is ever present, electric shock is of greatest concern. Statistics indicate that power tools are the second leading cause of electrical fatalities and lead all other shock causes by about 3 to 1.

Electric shock when using a power tool occurs most frequently when a person comes in contact with an energized metallic surface of a tool (handle or case) which is not intended to be a conductor of current, and at the same time is in contact with a suitable ground such as a wet or damp floor, water pipe or radiator. In such a case the body functions as an electrical conductor and conducts current from the "hot" case to the ground. Since only 100 to 200 milliamps passing through the body are lethal, and the "let-go" threshold is about 15 milliamps (can be as low as 10 - 11 milliamps) a fuse or circuit breaker offers no protection against shock.

The casing of a tool can become energized when wire insulation becomes brittle and cracks or breaks and the wire touches the interior of the case, or if through age and heat, the insulation deteriorates and "leaks" current. Overloading power tools causes excessive heating which, in turn, can encourage carbonization of certain insulating materials resulting in electrical leakage.

Power tool manufactures minimize electrical shock possibilities in two ways: 1) double insulating tools, or 2) connecting a third or grounding wire to typically non-current-conducting components. The grounding wire in case of internal failure conducts current to the ground, thereby protecting the user. In such an instance the fuse blows and the current is interrupted.

A tool with a grounding conductor has a 3-conductor power cord terminating in a 3-pronged grounding or polarizing plug. This fits into a 3-hole receptacle which in turn is grounded.

The use of a power tool without a 3-conductor cable and polarizing plug is not recommended except where the tool is both double insulated and approved by Underwriter's Laboratories, Inc. All power tools, whether double insulated or not, should bear the "U.L. label". The U.L. label for power tools as well as for other electrically operated devices must appear on the device and not just on the power cord. A label on a power cord only signifies that the cord is U.L. approved--NOT the appliance itself.

Power tools should be checked frequently to determine condition of cases, cords and plugs as well as continuity of grounding wires. It is important to recognize that a power tool can be unsafe and still be operative. In the event that the person using the defective tool comes in contact with a water pipe, damp floor, or for that matter a grounded metallic device on which he's working, the current can pass through the body causing electric shock.

The severity of electric shock is dependent upon several factors such as length of time of contact, whether or not vital organs are involved and amount of current passing through the body. The latter is influenced greatly by skin condition. Skin serves as insulation, but its insulating ability varies, depending on thickness and whether or not it is dry or damp--from perspiration, for example.

The amount of current flowing through the body is governed by the resistance of the body (particularly the skin at the point of entry and exit) and the degree to which the body is insulated from the ground. The skin offers about the only resistance presented by the human body to the flow of current.

When the skin is dry, it may present from 100,000 to as much as 600,000 ohms resistance, depending upon its thickness (0.015 to 0.025 inches) and on other personal factors. But the skin's humidity varies over wide limits. A person working under high temperatures may perspire freely and when the skin, and possible his clothing, becomes wet, the skin's resistance to electric current drops radically, quite easily to a figure of approximately 1,000 ohms. If working on damp or wet surfaces, or if there is a break in the skin, it could drop even more than this, at times to a few hundred ohms.

If resistance of the skin were reduced to 1,000 ohms because of perspiration, and if the person were standing on wet or damp ground, the current passing through the body would be in the nature of 120 ÷ 1,000 = 0.1 of an ampere (100 milliamperes)--more than enough to kill.

* Laboratory Safety. Vol. 13, No. 5. Department of Environmental Health and Safety, University of Michigan Health Service, Ann Arbor, Michigan.

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Appendix P:

SAFETY EQUIPMENT AND FACILITIES

A. Introduction

The following is a summary of "Emergency Equipment and Clothing" from Safety in Academic Chemistry Laboratories, American Chemical Society.

B. Facilities and Safety Equipment - General Checklist

All chemistry labs should have:

____ 1. Safety showers.
____ 2. Dry chemical powder or carbon dioxide-type fire extinguishers.
____ 3. Fume hoods.
____ 4. Eye protection devices for students and staff.
____ 5. Eye wash facilities.
____ 6. An alarm for evacuating laboratory. (Readily accessible to instructors.) It should sound only for lab concerned.
____ 7. Well marked, unimpeded exits.
____ 8. A general alarm system for the entire building.
____ 9. Provisions for safe storage and transportation of chemicals. (Incompatible chemicals should never be stored in close proximity).
____10. A carefully planned chemical disposal procedure. (Must follow EPA rules or other local, state and federal regulations). The following company will dispose of chemicals for schools: Nelson Chemicals, 12345 Shaefer, Detroit, MI, 933-1500.
____11. Protective clothing - lab aprons, coats, gloves made of a chemically inert material.
____12. First aid equipment with sufficient personnel trained in its use.
____13. A file of current safety publications. The file should be accessible to students and visitors. The instructor should encourage its use.

C. Emergency Equipment and Clothing

1. Eye Protection

a. Students must be provided with proper eye protection or required to provide their own. (glasses, goggles, face shields). Act No. 54 of the Public Acts of 1972. Enrolled Senate Bill No. 553.
b. Eye protective devices should be provided for visitors and personnel.
c. Contact lenses should be prohibited in the lab. If a chemical is splashed into the eye, it will become trapped under the lens and irrigation will be ineffective.
d. Devices should be sanitized after each use.

2. Eye Washes

a. Eye wash fountains should deliver a gentle flow of clean, aerated water.
b. A hand held eye wash spray with a 5-foot hose is more adaptable. Rubber tubing can be attached to a faucet for ready use. It may be used as an eye wash and as a head and body wash.
c. Eye wash devices should be flushed weekly.

d. Eye wash devices should not be located where they can be contaminated by wastes.
e. A 15 minute wash is recommended.

3. Fire Extinguishers

a. Extinguishers should be appropriate to the specific need. (An ABC type extinguisher is recommended for general use).
b. There should be at least one extinguisher for each work bench.
c. Extinguishers should be charged promptly after each use. (At least a 10 lb. charge).
d. At least one dry chemical powder-type extinguisher should be provided for back-up use.
e. Carbon tetrachloride and most other halohydrocarbons should not be used because of their hazards: toxicity of vapors, the decomposition products, and their chemical reactivity under fire conditions.
f. At least one fire blanket should be provided for ready use.

4. Refrigerators

a. Domestic refrigerators should not be used for chemical storage unless modified by removing sources of open electrical contacts (i.e., bulbs) and replacing the door closure with easily opened magnets.
b. In frost free refrigerators, bottom drain should be plugged to prevent spillage and vapors from coming in contact with the motor.
c. Food and chemicals should never be stored in the same refrigerator.
d. Stored chemicals must be securely closed and properly labeled.
e. A regular defrosting schedule should be maintained.
f. Old chemicals should be discarded.

5. Sinks

a. Lab sinks should have rubber or plastic mats in the sink and on the drain.
b. Each sink should have ample hot water and soap.
c. Drainage from lab sinks should be kept separate from sanitary drainage.

6. Safety Showers

a. The valve handle should be rigidly fixed and plainly labeled.
b. The valve should readily open in either direction and remain open until intentionally closed.
c. Water flow must be sufficient to drench the subject rapidly.
d. Shower area must be free from obstructions.
e. Pure, tempered water should be used.
f. Showers should be tested on a regular basis. A record should be kept of such tests.

7. Aspirators

a. Aspirators or aspirator bulbs should be used for drawing liquids into pipettes; never use the mouth.

Reference:

Safety in Academic Chemistry Laboratories, American Chemical Society, Committee on Chemical Safety, March, 1974, Revised January, 1976.

Appendix Q:

SAMPLE ACCIDENT REPORT FORM

Age ______ Sex ______ Grade ______

Name (Print) ____
(Last) (First)

Address ____________________ City ____________________ Phone __________

Parent/Guardian ______________________________ Business Phone __________

Teacher ____________________ Room ____________________ Class __________

Date & Time of Accident ______________________________________

Location of Accident ______________________________________

Nature of Injury ______________________________________

Treatment of Injury ______________________________________

Description of Accident: Give a complete description of what was taking place when the accident happened, location, equipment involved, witnesses, etc.

____

____

____

Check Cause:

____ 1. Experimenting or working without authority.
____ 2. Making safety devices inoperative.
____ 3. Failure to use personal protective devices.
____ 4. Distraction, teasing, horse play.
____ 5. Unsafe clothing or hair.
____ 6. Hazardous arrangement or experimenting.
____ 7. Ignored instructions.

What safeguards or protective equipment were being used at time of accident?

____

What safeguards should be used? ______________________________

____

What steps were taken to prevent similar injuries? ______________________

____

General Comments: ____

____

Appendix R:

SUPPLIERS FOR
SAFETY EQUIPMENT & SERVICES

Abso-Clean Chemical Company
17325 Lamont
Detroit, Michigan 48212
(Cleaning Chemicals & Equipment)

Aden Supply Company
5706 W. River Dr., N.E.
Belmont, Michigan 49306
(Safety Glasses)

Advertisers Publishing Co.
944 Wall Street, PO Box 602
Ann Arbor, Michigan 48107
(Custom imprinted safety awards)

Airkem Detroit, Inc.
404 West Eight Mile Road
Ferndale, Michigan 48220
(Odor Control)

The Ansul Company
16115 Meyers Road
Detroit, Michigan 48235
(Fire Protection Products)

Argus Supply Company
5940 Casmere
Detroit, Michigan 48212
(Ind. Safety & Fire Equipment)

A.J. Baxter & Company
10171 W. Jefferson
River Rouge, Michigan
(Industrial Safety Products)

Averill Equipment Company
19225 Conant Avenue
Detroit, Michigan 48234
(Safety Distributor)

Bemis & Son, Inc.
P.O. Box 151
Kalamazoo, Michigan
(Traffic Control)

Boyer Campbell & Sales
19460 Charleston
Detroit, Michigan 48203
(Safety Products)

Broner Glove Company
345 E. 9 Mile Road
Ferndale, Michigan 48220
(Industrial Work Gloves)

Contractor Machinery Company
13200 North End Avenue
Detroit, Michigan
(Construction Equipment)

Dockson Corporation
3839 Wabash Avenue
Detroit, Michigan 48208
(Head & Eye Protection)

Goodall Rubber Company of Michigan
13351 Cloverdale Avenue
Oak Park, Michigan 48237
(Industrial Rubber Goods)

Hastings Fiber Glass Products
770 S. Cook Rd., Box 218
Hastings, Michigan 49058
(Hot Line Maintenance Tools)

Howe Services, Inc.
National Bank Building
Birmingham, Michigan 48011
(Message Motivation Programs)

Hy-Test Div., International Shoe Co.
32302 Craftsbury
Farmington, Michigan
(Safety Shoes)

Jackson Products
5523 E. Nine Mile Road
Warren, Michigan 48091
(Safety Equipment & Welding Accessories)

Magline, Inc.
503 S. Mercer Street
Pinconning, Michigan 48650
(Magnesium Safety Blocks for Presses)

Mine Safety Appliances Company
19725 Ralston
Detroit, Michigan
(Safety Equipment)

National Safety Products, Inc.
116 North Hamilton Street
Saginaw, Michigan 48602
(Industrial Safety Equipment)

Port Products, Inc.
325 Main Street
Munith, Michigan
(Signs and Safety Equipment)

The Protectoseal Company
Power Materials Company
633 New Center Bldg.
Detroit, Michigan 48202
(Safety Containers)

R-J Distributing Company
11566 E. Nine Mile Road
Warren, Michigan 48089
(Reynolds Televator-Power Scaffold)

Safeco, Inc.
24295 Gibson Drive
Warren, Michigan 48090
(Industrial Safety)

Safety Products & Services, Inc.
184 Avenue A
Battle Creek, Michigan 49015
(Safety Equipment Sales & Service)

Safety Services, Inc.
407 East Michigan Avenue
Kalamazoo, Michigan 49006
(Industrial Safety Equipment Supplies)

Seco Manufacturing, Inc.
4461 W. Jefferson
Detroit, Michigan
(Safety Equipment and Supplies)

Speidel Safety Service
600 W. Commerce Road
Milford, Michigan 48042
(Industrial Safety Sales)

Standard Glove Company
28252 Terrace
Livonia, Michigan 48154
(Safety Gloves)

Stewart Oxygen Service
19142 James Couzens Highway
Detroit, Michigan 48235
(Oxygen Therapy Equipment)

Sugar Beet Products Company
302 Waller Street
Saginaw, Michigan 48605
(Industrial skin cleansers & medicated skin cream)

Tool Sales Company
46 Victor Avenue
Highland Park, Michigan 48203
(Safety Tools)

Wallace Optical
2870 E. Grand Blvd.
Detroit, Michigan
(Safety Glasses)

Wallace Opticians
107 N. Washington Avenue
Lansing, Michigan 48933
(Prescription Safety Glasses)

E.L. West Company
1020 E. Jolly Road
Lansing, Michigan 48910
(Construction Safety)

LeHigh Safety Shoe Company
14234 Woodmont Road
Detroit, Michigan 48227

Midwest Safety Supply
621 Liberty Street
Jackson, Michigan 49203
(Industrial Safety Equipment)

Fisher Scientific Co.
711 Forbes Ave.
Pittsburgh, Penn. 15219

Sargent Welch Scientific Co.
7300 North Linden Ave.
Skokie, Ill. 60076

Turtox/Cambosco
Macmillan Science Co. Inc.
8200 S. Hoyne Ave.
Chicago, Ill. 60620

Science Kit Inc.
777 East Park Drive
Tonawanda, New York 14150

Central Scientific Co. (CENCO)
2600 South Kostner CENCO Center
Chicago, Ill. 60623

Safety Education & Training Division
Bureau of Safety & Regulation
Michigan Department of Labor